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100 AMPERE-HOUR NICKEL CADMIUM BATTERY DEVELOPMENT PROGRAM

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FINAL REPORT

VOL. 2 of 2

Prepared for
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058

GRUMMAN

100 AMPERE-HOUR

NICKEL CADMIUM

BATTERY DEVELOPMENT PROGRAM

VOLUME II

S. Gaston

Grumman Aerospace Corporation

Bethpage, New York 11714

March 1974

Final Report

Prepared For:

National Aeronautics & Space Administration

Lyndon B. Johnson Space Center

Houston, Texas 77058

Contract NAS 9-11074

APPENDIX K

APPENDIX K-1

GRUMMAN AEROSPACE CORPORATION

PROJECT INTEROFFICE MEMO

Cell Terminal Development

D559-0-2

20 October 1970

MW

From: M. Wertheim - POD - Ext. 9142

To: S. Gaston

Subject: CELL IMPEDANCE AS A FUNCTION OF TERMINAL GEOMETRY

Reference: a) NAS9-11074
b) Eagle Picher Dwg. 85-40-138-5 "Terminal Assembly"

The writer is concerned that the present internal terminal geometry represents a potential problem with regard both to series equivalent resistance and series equivalent inductance. The latter, particularly, seems to be poorly handled, and the writer is concerned that the electrical-dynamic characteristics may be highly adversely effected.

It must be pointed out, at this juncture, that to do a complete analysis of the resistive-inductive effects would require detailed knowledge we do not have. In fact, due to the discontinuities in the termination construction, it is probable such an analysis will require a computer to provide an iteractive solution by a combination of regression and superposition techniques. Certain basic principles can, however, be pointed out. These follow:

1. Inductance

Inductance of a straight length of wire is (MKS [R] units)

$$F = \frac{m^2}{4\pi\mu\ell^2} \qquad \text{henry/meter} \qquad (1)$$

$m \equiv$ magnetic charge (weber)
$\mu \equiv B/H$
$\ell \equiv$ length (2)

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substituting (2) into (1)

$$F = \frac{m^2 H}{4\pi B \ell^2} \tag{3}$$

but $H = I/\ell$ (letting $n = 1$) ampere-turns/meter (4)
substituting in (3)

$$F = \frac{m^2 I}{4\pi B \ell^3} \quad \text{henry/meter} \tag{5}$$

Now $I = JA_c$, where $J \equiv$ current density across conductive area, A_c.

$$\text{Thus } F = \frac{m^2 J A_c}{4\pi B \ell^3} \quad \text{henry/meter} \tag{6}$$

Finally A_c is also the area through which B acts, & $\Phi = BA_c$ - - substituting:

$$F = \frac{m^2 J A_c^2}{4\pi \phi \ell^3} \quad \text{henry/meter} \tag{7}$$

As A_c changes, ϕ will change, J will change, and, finally, F will change.

$$\text{Therefore} \quad \frac{dF}{dA_c} = \frac{\partial \phi}{\partial J} \cdot \frac{\partial J}{\partial A_c} \cdot \frac{\partial F}{\partial \phi}$$

From 7, differentiating,

$$\frac{\partial \phi}{\partial J} = \frac{m^2 A_c^2}{4\pi F \ell^3} \tag{8}$$

$$\frac{\partial J}{\partial A_c} = -\frac{8\pi \phi \ell^3 F}{m^2 A_c^3} \tag{9}$$

$$\frac{\partial F}{\partial \phi} = -\frac{m^2 J A_c^2}{4\pi \ell^3} \tag{10}$$

Doing the indicated multiplication, and writing in differential form

$$dF = \frac{\phi m^2 J A_c}{2\pi \ell^3} \, dA_c \tag{11}$$

Dividing by F to find the rate of change of inductance per unit A_c

$$\frac{dF}{F} = \frac{2\phi^2}{A_c} dA_c = 2B\phi dA_c = 2B^2 A_c dA_c \qquad (12)$$

Resubstituting the definition previously noted

$$\frac{dF}{F} = \frac{2\mu^2 J^2 A_c^3}{\ell^2} dA_c \qquad \frac{\Delta\ \text{henry/meter}}{\text{henry/meter}} \qquad (13)$$

This demonstrates that the rate of change of inductance as A_c changes is a function of the <u>product</u> $\underline{\underline{J^2 A_c^3}}$

By superposition summation, actual total inductance can be derived from the plate to the terminal ($\ell = 0$ to $\ell = \ell_1$) for <u>each</u> plate end, and the terminal inductance obtained by paralleling the individual inductances. One problem is that A_c is extremely difficult to determine in spot welded joints - - thus seam or fusion welding is highly recommended.

2. <u>Resistance</u>

A similar analysis will show that dR/R is a function of the $J^2 A_c^2$ product. Thus, anything done to reduce equivalent series inductance will also reduce series resistance, but by a smaller amount.

Conclusion:

The internal terminal flags must be made deeper to decrease dA_c and increase A_c, decreasing J. The result will reduce series inductance materially, and avoid charge-loop problems. This should be done even if case height is penalized by .2 to .25 inches. A secondary result will be reduction of terminal hot-spots, improving reliability. It must be noted that if equivalent series inductance is .01-.05 μH (a probable value), and circuit Q of the cell is about 2-5 (also probable), the rate of change of charge current allowable will be in the order of several minutes. Higher rates will produce either severe instability or excessive cell power dissipation or both. It is worth noting that this may have been what Gulton called "polarization" losses, causing reversion to opposite end terminals. It would also be desireable to attempt to simulate the Gulton terminal design rather than simply try to change the present E-P design.

MW:mm

CC: J. K. Benz
E. E. Miller
D. Lehrfeld
A. Winegard/B. Lijoi
Sequist.

APPENDIX K-2

APPENDIX 1 TO NOVEMBER 1971 PROGRESS REPORT

ummary of Large Size Terminal Seal Problem, as discussed at NASA/GSFC Battery Workshop, November 17 and 18,1971

The large size terminal seal problem was discussed both at the general orkshop meeting and separately among E. Carr (Eagle Picher), R. Turner (Ceramaseal), nd S. Gaston (Grumman).

A short summary of the various opinions expressed, and possible solutions roposed are described below:

. A weakness in some large size Ceramaseal terminals was detected, which can give ise to cracking in the ceramic body and subsequent leakage through the seal. ughes attributes this to titanium diffusion into the ceramic. Titanium is used as n activator for the braze material).

This problem never occurred on the smaller size terminals for cells up to and ncluding 20 AH.

. Hughes' apparent solution is use of their own terminal design. This utilizes butt seal configuration and, apparently, inert components. There has been no valuation of this design on real cells to date, and none seems to be planned. They re, however, in process of marketing this terminal.

. The GE butt seal design performed well under extended cell testing on smaller zes (6 and 20 AH cells). No large size terminals have been tested. GE is presently onstructing a 3/8" diameter terminal. ($\frac{1}{2}$" diameter is used on the 100 AH cell for his program.) Cells with these terminal seals were purchased and will be valuated by TRW.

Ziegler seal - This compression-type seal has been reported for several years by ell Labs. Recently they have added a teflon ring to overcome an unspecified design oblem. The largest diameter terminal built and tested was 5/16". Bell apparently es not plan to market this seal. They prefer to license it to another manufacturer.

Therefore, an initial investment is required, as well as a "learning curve", before suitable large size terminal seals can be produced even in small quantities.

5. Ceramaseal - This seal (the current standard design) was evolved from commercial designs. It has shown certain shortcomings which should be corrected. Specifically, most ceramic bodies were supplied with a "glazed" silica coating to reduce foreign material accumulation on the surface. Since silica is attacked by the cells' KOH electrolyte, its presence can easily result in formation of a leakage path at the glazed surface. Hard potting compound is used around the terminal stud to fill the tolerance void. This potting has a significantly different thermal expansion coefficient than the other materials and could easily crack. When the need for larger size terminals arose, the smaller unit was simply scaled up.

To eliminate these problems, the following actions were suggested:

A) Increase the alumina purity from the present 94% minimum to 99.5% minimum. (There is also a high strength 99.9% alumina available from Coors. However, long delivery schedules preclude its use in the near future.) This change will result in lower silica content.

B) Eliminate the glaze - Again, surface attack by the electrolyte is thereby avoided. An increase in processing cleanliness level to avoid associated surface contamination is then required.

C) The "cap" and "flange" materials should be upgraded from 42% nickel (58% iron) to 52% nickel (48% iron). This will eliminate use of copper plating, which had been necessary to obtain a good braze joint. The presence of copper is undesirable since copper-oxide is soluble in the electrolyte.

D) The "cap" and flange parts should be spun and machined to obtain closer dimensional tolerances (±.001").

E) The ceramic diameter should have a closer tolerance (±.0005" appears feasible).

F) Greater control of the braze material quantity should be exercised.

G) General material and process quality control should be instituted. Ceramaseal has agreed to comply with the EP-MS-122.

H) Although no immediate solutions for the potting compounds thermal expansion problem presents itself, a continuing investigation is being made. Specific suggestions will be forthcoming as they are developed.

GRUMMAN AEROSPACE CORPORATION

AVOID VERBAL ORDERS

APPENDIX K-3

FROM S. Gaston	567/POD	35	9142	DATE 12/7/71
NAME	GROUP NO. & NAME	PLANT NO.	EXT.	

TO: J. Rogers, LM Subcontracts

NO. D559-1-33

SUBJECT: GRUMMAN'S REPLY ON THE CERAMIC SEAL REDESIGN, AS PROPOSED BY EAGLE PICHER

Reference: a) Contract NAS 9-11074
b) Grumman PO #0-15161
c) EP letter on this subject dated 11/30/71.

Enclosure: 1) EP-MS-122 "Quality Assurance Specification for the Manufacture of Ceramic to Metal Seals"
2) Appendix "A" to Grumman AVO D559-1-33

Please urgently transmit the below listed Grumman comments on the ceramic seal redesign to Eagle Picher for immediate action.

1. Grumman hereby approves the Eagle Picher recommended changes listed in the above Reference c) document and listed below:

List of Changes

a. Increase the ceramic purity to 99.4% minimum alumina content.
b. Eliminate the glaze on the ceramic.
c. Make "cap" and "flange" parts from 52% nickel-iron alloy. Parts are to be spun and machined.
d. The ceramic outer diameter shall be 0.750 $\pm$.0005 inch.
e. The metal parts diameter joining the ceramic shall be 0.756 $\pm$.001 inch.
f. A greater control on the amount of braze shall occur.

2. The seal redesign listed above shall become effective immediately and shall be applicable starting with the next 27 cell group (Reference b) purchase order, Section A, Items No. 4.0-6.0). It seems advisable at this point to construct terminals for the 27 cell group only and wait for some preliminary test results until the terminal construction for the life test cells will start (PO Section A, Items 7.0 and 8.0), especially until the cells' mechanical tests have been successfully completed. However, a review of the present cell construction schedule is required to assess the situation. Eagle Picher is to review the present cell construction schedule and to submit their comments on this concern to Grumman. A good compromise with respect to the schedule appears to be by purchasing the terminal components for the life cells now and hold-off their assembly until some test results on the next 27 cell group are available.

3. Grumman feels that the stated ten week Ceramaseal delivery schedule is unrealistic and could be shortened. Grumman will assist EP in reducing this delivery schedule, if this assistance is desired by them.

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4. Grumman has the following comments on the document action for the terminals. These comments should not delay the go-ahead in the purchasing cycle. However, they must be seriously considered and must be complied with on cells under this contract.

   a. The EP cell assembly, cover assembly and terminal drawings shall be finalized by EP incorporating Grumman comments issued in AVO D559-1-24, dated August 20, 1971. Up to date no response from Eagle Picher on this memo has been received by Grumman. The terminal dimensions listed in Grumman drawing no. 559-104 AV must be kept.
   b. Supply the ceramic material strength data for 99.4% vs. 94% alumina material as requested by the writer at the Battery Workshop meeting last month.

   c. Grumman has reviewed the EP MS-122 document. Comments are shown in Enclosure 2. to this AVO. These comments shall be reviewed and complied with by Eagle Picher.

   d. Supply a reply on how "greater control on the amount of braze" is executed by Ceramaseal.

5. EP is to submit all cost breakdown documentation for all cost changes listed in above Reference c) document to review the cost impact to this purchase order.

INFO cc:

J. Benz
J. Cioni, NASA/MSC
E. Carr, EP
F. Ford, NASA/GSFC
G. Foster, QC
W. Harsch
R. Mallard, GAC at EP
E. Miller
R. Wannamaker, NAVPRO

APPENDIX K-3

EP-MS-122

QUALITY ASSURANCE SPECIFICATION
FOR THE MANUFACTURE OF
CERAMIC-TO-METAL SEALS

13 AUGUST 1971

EAGLE-PICHER INDUSTRIES, INC.
ELECTRONICS DIVISION
COUPLES DEPARTMENT
JOPLIN, MISSOURI

Lee Miller
Engineering

Quality Assurance

QUALITY ASSURANCE SPECIFICATION FOR THE MANUFACTURE OF CERAMIC-TO-METAL SEALS

1.0 SCOPE

1.1 This document contains the minimum requirements necessary for the production of ceramic-to-metal seals for use in high reliability nickel-cadmium spacecraft cells.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of receipt of this document are to be considered an integral part to the extent specified herein.

Standards

Military

MIL-STD-100	Engineering Drawing Practices
MIL-STD-105D	Sampling Procedures & Tables For Inspection by Attributes
MIL-STD-271D	Nondestructive Testing Requirements For Metals
MIL-STD-767A	Cleaning Requirements For Special Purpose Equipment Including Piping Systems

Federal

FED-STD-151	Metals; Test Methods

Specifications

Military

MIL-B-7883B	Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum & Aluminum Alloys
MIL-I-10A	Insulating Materials, Electrical, Ceramic, Class L
MIL-W-8611A	Welding, Metal Arc & Gas, Steels & Corrosion & Heat Resistant Alloys; Process For

NASA

S-716-P-23	Interim Model Specification For High Reliability Nickel-Cadmium Spacecraft Cells

AEC

SS209887	Resistance Welding
9902119	Plating, Electrodeposited, General Requirements
400220	Class 2 Welds In Corrosion Resistant Steels

3.0 MATERIALS INSPECTION

3.1 Metal Parts

3.1.1 Metal parts (cell cover, terminals, stress relief collars, braze cups, etc.) shall be sample inspected under 10X magnification for visual defects such as blemishes, pits, cuts, cracks, file marks, weak points, incomplete penetration, etc. (AQL Level II 1.0 per MIL-STD-105D). Any such defects which could conceivably interfere with the intended function of the final assembly shall be considered cause for rejection.

3.1.2 Metal parts shall be sample inspected for dimensional conformance to specific drawings (AQL Level II 1.0 per MIL-STD-105D). Dimension and tolerances not specified shall be interpreted per MIL-STD-100. Where it is impossible to measure the thickness of formed parts, a minimum of five (5) parts shall be sectioned to verify they do not exhibit excessive thinning.

3.1.3 The vendor is responsible for obtaining material certifications containing the following minimum information - supplier name, alloy designation, batch number, and certified analysis of chemical composition and physical properties. The vendor shall also perform lot verification spectrographic analysis tests. Testing shall be in conformance with FED-STD-151.

3.2 Ceramic Bodies

3.2.1 A 100% visual inspection is required of all ceramic bodies.

3.2.2 Material shall be white in color and uniform in texture; areas of discoloration exceeding 10% of the surface area are not acceptable. Discoloration is not permitted in any areas designated as "seal" areas.

3.2.3 Adhesions, bumps, inclusions, chips, or holes are not acceptable if they are excessive or exceed dimensional tolerances. Such surface defects are not permitted on any surfaces designated as "seal" areas.

3.2.4 Unglazed surfaces must be clean and free of contamination that cannot be removed without injury to the surface of the ceramic body.

3.2.5 Glazed surfaces must be smooth and continuous and have a glossy appearance. Surfaces must be clean and free of dirt, smudges, or metallic deposits that cannot be removed without injury to the surface.

Thickness of glaze must be sufficient to cover minor surface imperfections. Cracks or crazing in or under the glaze are not acceptable. Surface glazing shall be limited to ceramic surfaces located outside of the cell. Surfaces designated as "seal" areas shall be completely free of glaze.

3.2.6 Ceramic bodies shall be sample inspected for dimensional conformance to specific drawings (AQL Level II 1.0 per MIL-STD-105D). Dimensions and tolerances not specified shall be interpreted per MIL-STD-100.

3.2.7 Inspect 100% for porosity by dye penetration method per MIL-I-10A. In conjunction, parts shall be inspected 100% for visible cracks which are not acceptable.

3.2.8 Ceramic bodies shall be sample inspected for specific gravity (AQL Level II 1.0 per MIL-STD-105D). Results must fall within manufacturer's specified limits.

3.2.9 The vendor shall be responsible for obtaining material certifications containing the following minimum information: Supplier name, ceramic designation, lot number, and certified analysis of chemical composition and physical properties. The vendor shall also perform lot verification spectrographic analysis tests.

3.3 <u>Brazing, Sintered Metal Powder Process (Moly-Manganese) And Active Metal Process Materials</u>

3.3.1 The braze alloy shall be of vacuum tube quality with a minimum carbon content and a low vapor pressure.

3.3.2 The vendor shall be responsible for assuring that a braze flag test is performed on each lot of brazing alloy to determine solidus and liquidus points. The results shall be in conformance with applicable braze alloy specifications.

3.3.3 The particle size and particle size distribution shall be determined for each lot of sintered metal powder (moly-manganese) metallizing material. The results shall be in conformance with definite limits determined by previous successful manufacturing experience.

3.3.4 The vendor shall be responsible for obtaining material certifications containing the following minimum information: Supplier name, material designation, lot number, and certified analysis of chemical composition and physical properties. The vendor shall also perform lot verification spectrographic analysis tests. Testing shall be in conformance with FED-STD-151.

4.0 MATERIALS CLEANING AND HANDLING

4.1 Metal Parts

4.1.1 Chemical cleaning shall be utilized on all metal parts and a combination of chemical cleaning and furnace firing shall be utilized on upper braze cups and stress relief collars in preparation for the vacuum brazing operations. The chemical cleaning process shall conform to MIL-STD-767A.

4.2 Ceramic Bodies

4.2.1 Ceramic bodies shall first be cleaned in an ultrasonic bath using Freon followed by a deionized water wash. The ceramic bodies shall then be air fired in a furnace at a temperature of 1000°C ± 50°C for a period of one (1) to four (4) hours.

4.3 Handling Procedures

4.3.1 Parts shall be handled in such a fashion as to preclude any possibility of contamination by impurities or oils. Parts are to be handled using only clean, white, lint-free gloves or bone-tipped tweezers.

4.4 Storage Procedures

4.4.1 Individual parts shall be stored immediately after completion of Sections 4.1 and 4.2 in clean, covered containers in a manner to prevent damage. Parts subject to corrosion shall be stored in a sealed container utilizing a desiccant. Ceramic bodies shall be stored in compartmentized containers.

5.0 PREPRODUCTION MATERIALS QUALIFICATION

5.1 Each new lot of braze, sintered metal powder (moly-manganese) or active metal and ceramic materials shall be qualified before use in production.

5.1.1 A minimum of three (3) cover assemblies shall be fabricated under the exact same conditions and controls as are utilized in the production process. Each assembly shall be subjected to the proposed ASTM Tensile Test (S-716-P-23).* Failure of a seal below a pressure of 600 pounds per inch of ceramic diameter shall be considered cause for rejection.

5.1.2 Cover assemblies which pass Section 5.1.1, shall be subjected to a destructive test. The Tensile Test shall continue until seal failure occurs; the force required to produce failure and the place of failure shall be recorded. A "Peel Test" shall then be performed to verify the integrity of the seal. Break the ceramic material away from the inside circumference of the seal's metal counterpart which defines the actual band of seal area. Examine the seal area under 10X magnification. An indication of non-adhesion areas (evidenced by an exposed metal surface) totaling more than 20% of the band area or the indication of a point any place around the circumference of the band in which the width of the adhesion area is less than 50% of the width of the band shall be considered cause for rejection. *See Addendum.

6.0 COVER ASSEMBLY PROCESSING

6.1 Mechanical Fixturing

Prior to the assembling operation, all mating surfaces shall be subjected to a 100% visual inspection for burrs or other protrusions. Burrs or protrusions which interfere with the proper fitting of parts or the flow of braze material shall be removed.

6.1.1 Mechanical fixturing shall be adequate to insure maintenance of part positions during the brazing operation. Self-jigging features shall be included where possible. Particular attention shall be given to the alignment of terminal and ceramic sleeve to maintain concentricity. Fixtures used to hold parts and assemblies in alignment during brazing shall be designed to allow expansion of the parts during heating and contraction during cooling. Jigs, fixtures, and clamps shall be of noncontaminative materials and should only involve point or line contact.

6.2 Cleaning

6.2.1 Just prior to the brazing operation, parts and fixtures shall be cleaned in an ultrasonic bath using Freon. No more than 8 hours shall be allowed to elapse between the start of this last cleaning operation and the completion of the final assembly brazing operation. Provisions shall be made for the periodic cleaning of fixtures.

6.3 Metallizing Coating (Sintered Metal and Active Metal Processes)

6.3.1 The metallizing coating bands on the ceramic body shall be measured for thickness and uniformity on a sample basis (AQL Level II 1.0 per MIL-STD-105D).

6.3.2 A 100% visual inspection under 10X magnification shall be performed. Pinholes, thin areas, and poor coverage shall be considered cause for rejection.

6.4 Vacuum Bell Jar Furnace

6.4.1 Prior to a production run, a test shall be performed to determine the temperature uniformity of the controlled hot zone. The results must fall within the vendor's specified limits.

6.5 Brazing Operation

6.5.1 The brazing operation shall be in conformance with MIL-B-7883B.

6.6 Electric-Arc Welding

6.6.1 Electric-arc welding on cover assemblies shall use inert gas shielding and shall be in conformance with MIL-W-8611.

6.6.2 Heat sink fixture shall be utilized to protect the ceramic-to-metal seal areas during welding operations.

6.7 Resistance Welding

6.7.1 Resistance welding on cover assemblies shall be in conformance with SS209887.

6.8 Plating (If applicable)

6.8.1 Cover assemblies shall be fixtured in such a fashion as to prevent excess plating solutions from entering the ceramic-metal terminal vents.

6.8.2 Plating applied to cover assemblies shall be in conformance with 9902119.

7.0 COVER ASSEMBLY INSPECTION REQUIREMENTS

7.1 Visual, 100%, 10X Magnification

7.1.1 Metal surfaces shall be inspected per Section 3.1.1. Evidence of surface defects described therein shall be considered cause for rejection.

7.1.2 Ceramic surfaces shall be inspected per Sections 3.2.1, 3.2.2, 3.2.3 and 3.2.4. Evidence of surface defects described therein shall be considered cause for rejection.

7.1.3 Braze joints shall be inspected per Section 4.4.1 of MIL-B-7883B.

7.1.4 Electric-arc weld joints shall be inspected per Section 4.3.1 and Table 1 of 400220.

7.1.5 Resistance weld joints shall be inspected per Section 3.7.3.1 of SS209887.

7.1.6 Evidence of stains or wetness caused by plating solution leakage on the cover surface in the vicinity of the ceramic terminal post seal shall be considered cause for rejection.

7.2 Dimensional

7.2.1 Cover assemblies shall be sample inspected for dimension conformance to specific drawing (AQL Level II 1.0 per MIL-STD-105D). Dimension and tolerances not specified shall be interpreted per MIL-STD-100.

7.3 Insulation Resistance

7.3.1 Cover assemblies shall be inspected 100% for insulator resistance. The electrical resistance between the terminal post and the cover shall be 100 megohms or greater when measured at a potential of 50 volts DC.

7.4 Leak Test

7.4.1 Cover assemblies shall be inspected 100% for leaks. The procedure used shall be helium leak testing per Section 6 of MIL-STD-271D. Cover assemblies shall exhibit a maximum leak rate of 1×10^{-8} cc's per second of helium.

7.5 Radiographic Examination

7.5.1 Braze joints shall be subjected to a sample radiographic examination per Section 4.4.2 of MIL-B-7883B (AQL Level II 1.0 per MIL-STD-105D). The provisions of this section shall be performed only if directed by the purchase order.

7.6 Tensile Test

7.6.1 A minimum of one (1) cover assembly but not less than 4% of a day's production shall be randomly selected from a day's production and subjected to the Tensile Test and inspection defined by Sections 5.1.1 and 5.1.2. A failure at this point will require notification of the Buyer for instruction on the disposition of that day's production.

8.0 QUALITY ASSURANCE PROVISIONS

8.1 Inspection Responsibility

8.1.1 Unless otherwise specified in the contract or purchase order, the vendor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the vendor may utilize his own facilities or any commercial laboratory acceptable to the Government.

8.2 Quality Program

8.2.1 The vendor shall establish, maintain, and operate a quality program to assure compliance with all requirements specified herein. The program shall include, but is not limited to the following provisions:

8.2.1.1 Quality Control Procedures and Instructions shall be written and kept current for all manufacturing and inspection operations associated with the Buyer's contract. Specific quality control inspection procedures shall be used for all inspection operations and shall be available at all points of use.

8.2.1.2 Controls shall be established and maintained over the manufacturing processes to assure conformance of the product to drawings and specifications. Both inspections and controls shall be designed to assure continuous control of the quality of parts, sub-assemblies and assemblies.

8.2.1.3 Records shall be maintained on all manufacturing processes, inspections, tests and evaluations. These records shall include data concerning both conformity and non-conforming products. Quality data from all available sources shall be systematically collected, analyzed and utilized for the prevention, detection and correction of deficiencies.

8.2.1.4 Subcontractors shall be evaluated to ascertain their capabilities to provide the required services and materials, and that necessary quality controls exist during the period in which material is being produced and delivered. Records of evaluation shall be matained as long as the subcontractor is a current procurement source.

8.2.1.5 Suitable methods and facilities shall be provided for controlling the identification, handling, shipping and storage of material from the time of receipt until delivery to Buyer. Procedures shall be established to assure nonconforming materials receive positive identification and prompt and continued segregation from other material being processed or stored.

8.2.1.6 The vendor shall establish and maintain a system for the calibration of all measuring instruments, test equipment and standards. Calibration intervals shall be established for each item on the basis of stability, purpose and degree of usage. Calibrations shall be performed against standards which have the capabilities for accuracy, stability, and range required for the intended use. Calibration procedures shall be utilized and a record, labeling and recall system shall be provided. Calibrations and measurements shall be performed by qualified personnel in an environment controlled to the extent necessary to assure the required accuracy. Vendor shall assure that subcontractors have an adequate calibration program.

8.3 Document Submittal

8.3.1 Each lot of cover assemblies submitted to the Buyer shall be accompanied by the following documents:

8.3.1.1 Certification of compliance with drawings and specifications.

8.3.1.2 Material certifications (see 3.1.4, 3.2.4 and 3.3.3) including vendors quantitative data from verification tests.

8.3.1.3 A brief technical report summarizing qualitatively and quantitatively the results of the tests and inspections performed under Sections 5.0 and 7.0.

9.0 PACKAGING

9.1 Containers

9.1.1 Cover assemblies shall be packaged for shipment in individually compartmentized sealed containers. Each cover assembly shall be sealed in a polyethylene bag or equivalent sealed moisture-free envelope. The atmosphere inside the container shall be maintained relatively moisture-free by the addition of a desiccant. Packing shall be in accordance with the best commercial practice and shall be sufficient to prevent damage to the cover assemblies during shipment.

ADDENDUM

The following is an alternate test procedure which may be used until such time as the proposed ASTM Test is formalized.

"Place cover assembly in dye and oven dry. Support assembly and push on terminal post from cover end until failure occurs."

APPENDIX "A"

Enclosure 2 to AVO D559-1-33

Grumman comments on Eagle-Picher document EP-MS-122 "Quality Assurance Specification for the Manufacture of Ceramic-to-Metal Seals".

a. General

1. One copy of all technical data, reports, certification, analysis reports etc. shall be furnished to Grumman.

b. Specific

1. On Page 1 - under Applicable Documents - the GAC cell spec AV-D559CS-1 shall be called out.
2. On Page 2, Paragraph 3.1.1 - Define "blemish, pit, cut, crack, incomplete penetration" etc.. If these areas are not defined this inspection is severely weakened and becomes non-objective.
3. On Page 3, Paragraph 3.2.4 - Define "without injury". How is this to be determined?
4. On Page 4, Paragraph 3.2.7 - Dye Penetration - What assurances are taken to remove the dye penetrant completely before further processing.
5. On Page 4, Paragraph 3.2.8 - Supply procedure and results to Grumman.
6. On Page 4, Paragraph 3.3 - Change minimum "carbon content" to a maximum tolerance value.
7. On Page 5, Paragraph 4.1.1 - Specify furnace firing maximum and minimum temperatures.
8. On Page 5, Paragraph 4.2.1 - Specify details for ultra-sonic cleaning, such as vibration range, time temperature etc.. Why is such a large time span of 1 to 4 hours specified? Suggest a closer tolerance be specified.
9. On Page 6, Paragraph 5.0 - Add that all of the units subjected to the tests specified herein shall not be supplied as production units.
10. On Page 6, Paragraph 5.1.1 - It seems that "600" should be "6000". See Grumman spec. AV-D559CS-1, Paragraph 3.4.6.1.4, Lot Tensile Test.
11. On Page 7, Paragraph C.2 - Add that all components shall be handled with lint free cotton gloves after cleaning.
12. On Page 7, Paragraph C.3.2 - Carefully define the listed rejection criteria.
13. On Page 7, Paragraph 6.4 - Supply details to Grumman.
14. On Page 8, Paragraph 7.0 - Incorporate the sample terminal requirement per AV-559CS-1 spec. Paragraph 3.4.6.1.5.
15. On Page 9, Paragraph 7.3 - Second sentence - change "the terminal post" to "each terminal post".
16. On Page 9, Paragraph 7.4 - See Grumman spec. AV-D559CS-1, Paragraph 3.4.6.1.11 for additional requirements.
17. On Page 11, Paragraph 8.2 - Add "one copy of all applicable EP and Cerama-seal QA documents shall be supplied to Grumman. Subsequent revision, changes or modifications shall be submitted to Grumman for approval prior to implementation. All records shall be kept for a minimum of (five) 5 years and furnished to Grumman upon request.
18. On Page 11, Paragraph 8.2.1.5 - Eagle Picher shall also establish an identification and control procedure to assure complete tracibility from a cell serial number to the terminal component lot.

AVOID VERBAL ORDERS

APPENDIX K-4

FROM: S. Gaston (signature) — NAME: S. Gaston — GROUP NO. & NAME: 553/POD — PLANT NO.: 35 — EXT.: 84212 — DATE: 2/23/72

TO: J. Rogers, LM Subcontracts
E. Carr/W. Harsch

NO. D559-2-2

SUBJECT: 100 A.H. BATTERY DEVELOPMENT PROGRAM - METALLURGICAL ANALYSIS OF TERMINALS FROM CELL S/N 14.

Reference: a) Contract NAS 9-11074
b) Grumman PO #0-15161
c) EP Group I Development Cell S/N 14
d) GAC AVO D559-1-33

The positive and negative terminals of cell S/N 14 have received a metallurgical analysis at Grumman. Attached to this AVO are crossectional views of these terminals. The pictures clearly show a cracking of the ceramic under the braze joint. In addition voids in the braze are noticeable. These samples confirm the findings by Hughes Aircraft, reported in the 1971 NASA/GSFC-Aerospace Industry Battery Workshop, Transcript of Proceedings, page 57A. The probable causes reported by Hughes appear reasonable.

It is hereby requested that these findings be immediately transmitted to Ceramaseal for information. In addition, Ceramaseal shall examine metallurgically a sufficient number of the terminals, presently being constructed under the authorization of reference d) AVO, to assure seal integrity. Two (2) randomly selected samples of these terminals shall be submitted to Grumman for examination. These must show freedom from both the defects herein noted, and any other problem affecting seal integrity. Combined results of Ceramaseal's and Grumman's examinations and tests must be reviewed and approved by Grumman before any seals of the current lot are used for cell header construction. The same procedure shall be used for the last cell group (Life Test).

Grumman shall be notified as soon as Ceramaseal's program is underway. Further, it is requested that Grumman be informed when the samples for examination will be available. Response is requested no later than March 8, 1972.

INFO cc:
J. Cioni NASA/MSC
F. Ford NASA/GSFC
J. Greenspan
T. Hine
R. Mallard, GAC/EP
M. Wertheim
R. Wannamaker, NAVPRO
S. Orehosky

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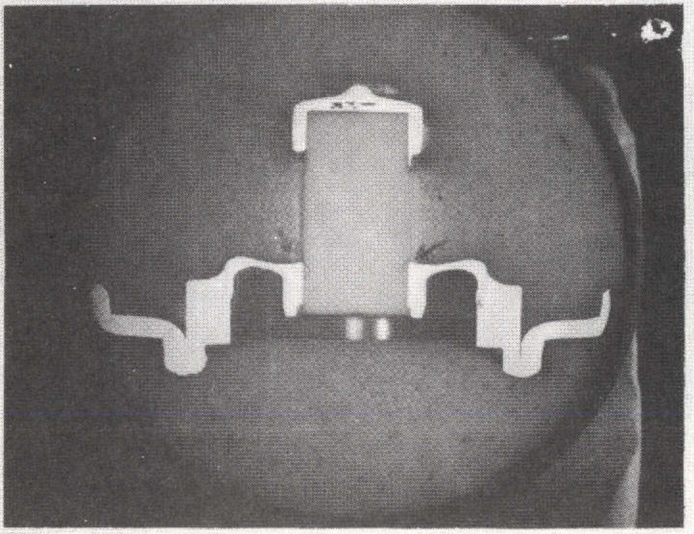
GAC 377 REV. 4

SN 14



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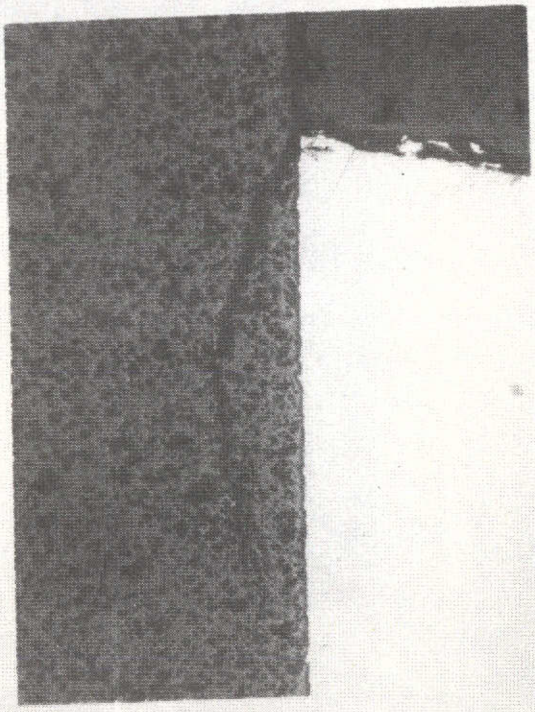

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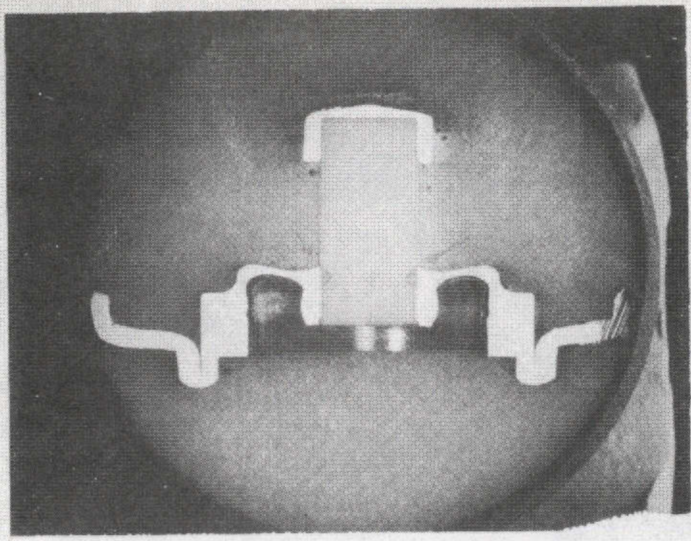
GRUMMAN

NEGATIVE TERMINAL

SN14



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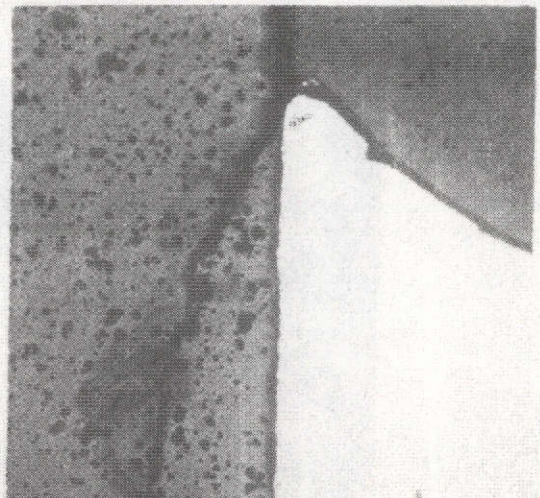

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GRUMMAN

POSITIVE TERMINAL

GRUMMAN INTER-OFFICE MEMORANDUM

APPENDIX K-4

FROM: J. A. Winn	Metallurgy/Welding	12	7351	**DATE**	31 May 1972
NAME	GROUP NO. & NAME	PLANT NO.	EXT.		
TO: S. Gaston	553	35		**NO.**	M&P/MWE-1-IM-72-69

SUBJECT: EVALUATION OF TERMINALS FROM CELL S/N 14-100 A.H. BATTERY DEVELOPMENT PROGRAM

References: (a) Request to laboratory, S. Gaston to J. Greenspan, dated 2-4-72, No. 22294

(b) Hughes Aircraft Company Report, dated 13 August 1971, Reference 71 (41) - 08292/C1278-002

Conclusion:

1. In all areas metallographically examined, the braze-to-ceramic joint appeared to be sound; no braze diffusion into the alumina ceramic was observed.

2. In each of three planes metallographically examined, on both the negative and positive terminals, a crack was observed in the ceramic at the top of the braze fillet in the braze joint of the stress relief member.

3. Some minor voids were observed in the braze alloy.

4. No other signs of an electrolyte leak path was evident in the surfaces examined.

Discussion:

The positive and negative terminals from Eagle-Picher cell S/N 14 were submitted for laboratory evaluation. The terminal seals were purchased from Ceramaseal Incorporated and consisted of a cup (42% Ni, Cu rem.) and stress relief collar (42% Ni, Cu rem.) with the metal-ceramic bond (braze: Ag-Cu + 5% Pd) on the outer circumferential surface of the 94% alumina ceramic body (Figure 1).

Both the negative and positive terminals were sectioned from the cover segment. The terminals were mounted in a metallographic epoxide medium for sectioning and metallographic preparation and were sectioned vertically for examination.

The terminals were each examined at three different planes. The planes relative to the O.D. of the ceramic were at 1/16", 3/16" and 3/8". The braze/ceramic interface in each of the planes was microscopically examined at 100X and 250X magnification. Typical areas observed were photographed (Figures 2 and 3). The surfaces were examined in the as-polished condition in order to prevent any detrimental attack to the braze from the etchant.

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All braze areas appeared to be satisfactory. However, in each of the three planes examined in both terminals, a crack was present in the ceramic at the top of the braze fillet in the joint of the stress relief member. As these cracks were evident in each plane and at points 180° apart it may be concluded that the crack continued around the periphery of the ceramic. A typical crack condition was documented at 100X magnification (Figure 2).

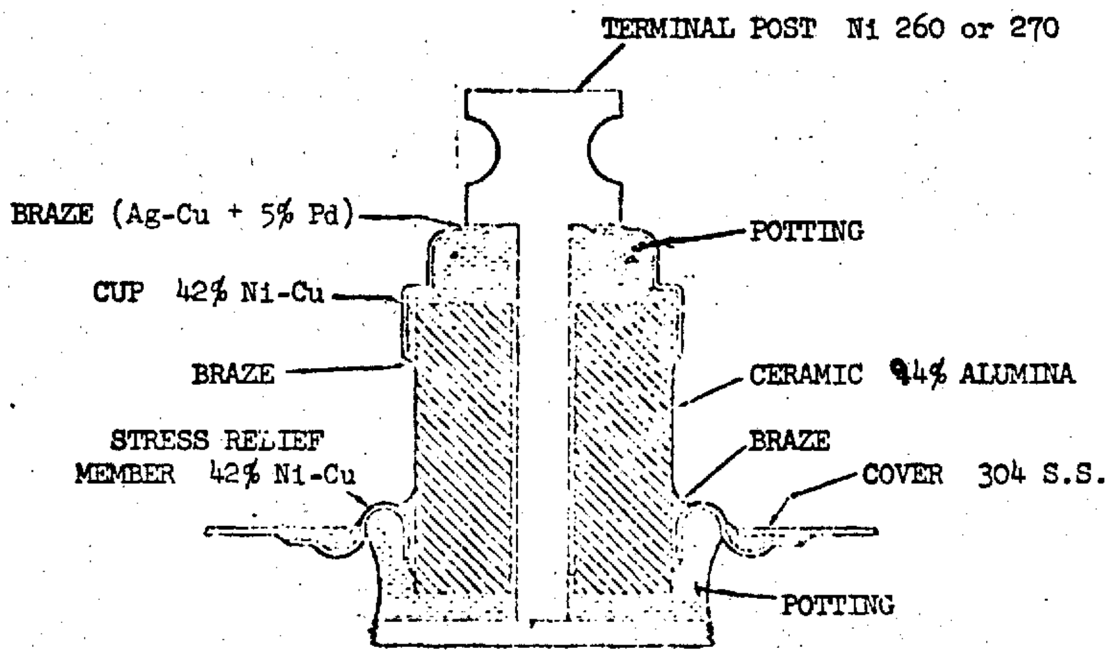
Microscopic examination of the remaining areas revealed no other signs of an electrolyte leak path through the terminal assembly.

JAW:jb

cc: T. Main/J. Meinhardt
T. Wolfe

T. Barbero
J. Brennan
E. Caprioglio
N. Franzese
A. Gelderman
P. Kraus
R. Pellicione
C. Turner
R. Tuttle
C. Weizenecker
A. Wirth
R. Wood

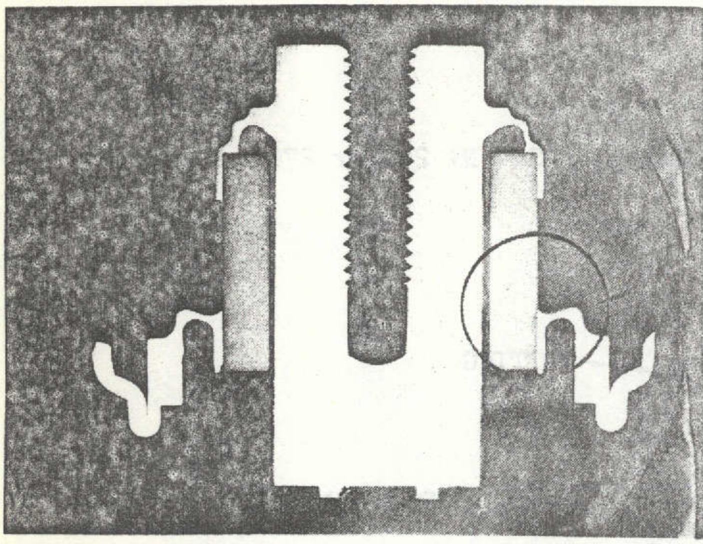
J. Greenspan



EAGLE-PICHER CERAMIC-TO-METAL TERMINAL SEAL

FIGURE 1

Typical construction of terminal.



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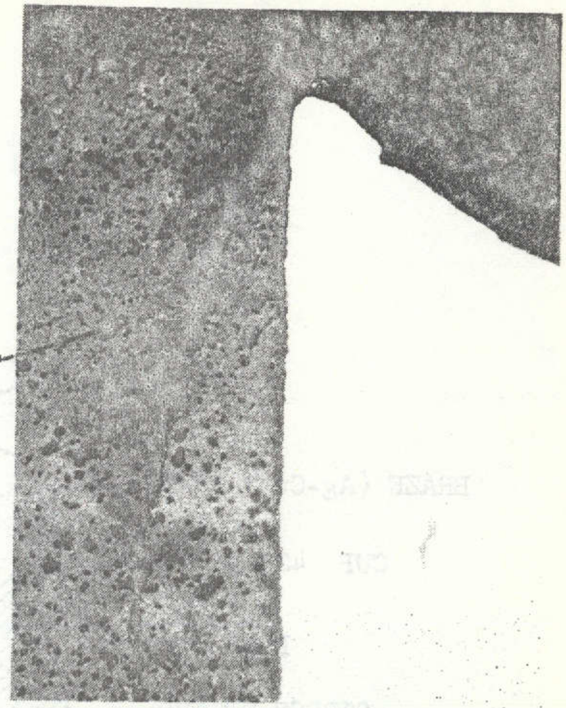


Mag: 100X

FIGURE 2

Left - cross section of terminal showing location of crack. Right - enlarged view of crack in ceramic at braze/ceramic interface at top of braze fillet. This type of crack was observed at both terminals.

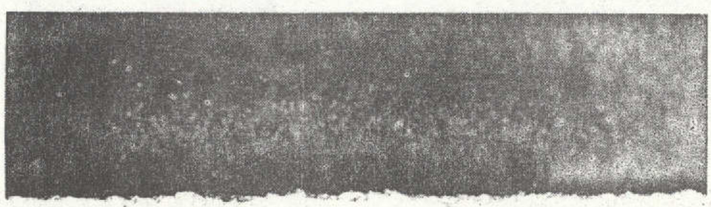


FIGURE 3 Positive Terminal Mag: 250X

Braze/ceramic interface at stress relief member surface.

APPENDIX K-5

FROM: S. Gaston (signed) | POD/553 | 35 | X84212 | DATE 27 December 1972

NAME | GROUP NO. & NAME | PLANT NO. | EXT. | NO. AVO D559-2-39

TO: J. Rogers, LM Subcontracts

SUBJECT: 100 A. H. BATTERY DEVELOPMENT PROGRAM - REQUEST TO EAGLE-PICHER TO RESOLVE CELL TERMINAL DESIGN AND TO ENFORCE QUALITY ASSURANCE PROVISIONS ON LAST GROUP OF DELIVERABLE CELLS

REFERENCE:
a) Contract NAS 9-11074
b) Grumman P.O. #015161, Section B, Items 7.0 + 8.0
c) Transcript of Proceedings of the NASA/Goddard-Aerospace Battery Industry Battery Workshop, 1971
d) Grumman AVO D559-1-33, dated 12/7/71
e) E.P. MS-122 "Quality Assurance Specification for Manufacture of Ceramic-To-Metal Seals"

ENCLOSURE: 1) Summary of Battery Cell Terminal Status and Immediate Steps to be Taken to Complete Last Group of Cells

Please transmit attached Enclosure 1 for immediate action by Eagle-Picher to complete the last group of cells.

INFO cc:

E. Carr, Eagle-Picher
J. Cioni, NASA/HOUSTON
F. Ford, NASA/GSFC
E. Miller
T. Hine
M. Wertheim

ENCLOSURE 1 to AVO D559-2-39

IMMEDIATE STEPS TO BE TAKEN TO COMPLETE LAST GROUP OF CELLS

1. **Background Summary:**

Cell terminal seal weaknesses have troubled the 100 A. H. Battery Development Program since its inception. These weaknesses were described in a number of this program's monthly progress reports and discussed and documented in Ref. c). Attempts to resolve them successfully had failed in the past to the point that a number of recently constructed parametric test cells have shown terminal seal leakage, from shortly after construction through after delivery to Grumman, necessitating the use of potting around seal areas. This fix is and cannot be acceptable for life test cells (see Ref. b) presently under construction, since seal integrity is a life limiting factor. As a result, Ceramaseal was requested to consider using their recently developed "Butt Seal" terminal design for these cells. One sample cell cover with two "Butt Seal" terminals was furnished to Grumman (received on November 10, 1972) for a leak test and metallurgical analysis.

A leak test on these terminals showed that they can successfully pass the maximum specified helium leak rate. Subsequent metallurgical analysis verified that this terminal looks superior to those supplied previously. A few improvements are indicated in the following areas:

1. Better cleaning at bottom weld to cover - a burr was left at the cup and weld penetration could be improved.
2. Incomplete braze penetration - braze material flows toward the perimeter leaving less material near the inner diameter.

   Note: Photographs taken of the above are being reproduced and will be issued later in an addendum to this AVO.

To strengthen this terminal design in the areas outlined above and to expedite delivery of the life test cells with this terminal, Eagle-Picher was contacted to arrange a meeting with Ceramaseal at the Grumman Metallurgical Laboratory as soon as possible.

This meeting was held on December 12, 1972. It was attended by W. Harsch (Eagle-Picher); R. Turner, M. Bredbenner (Ceramaseal), and S. Gaston, M. Wertheim, J. Greenspan, J. Winn, P. Dent (Grumman). Ceramaseal indicated during this meeting that additional modifications were made on this terminal since the sample

1. Background Summary (Cont'd)

was constructed. They also felt that the above comments were valuable, but that this design will do the job and meet requirements. They will undertake no additional development work on this program due to lack of additional funds, but will strive to achieve desired improvements.

2. Action Required:

Since the life test cell delivery is long overdue, with concomitant serious delays in the start of this test phase, the following immediate and quick action is necessary.

1. Assurance must be given that the finalized terminal must be of "good quality". That is, that all of them can pass their helium leak rate requirements and components are de-burred and clean prior to brazing or welding. That a good braze and weld joint has been obtained without fissures in the ceramic. A minimum number of samples shall be metallurgically examined to assure good weld and braze integrity. As soon as this goal has been achieved, no further design or manufacturing technique changes are permissible on all life test cell terminals.

2. Copies of all data obtained and magnified metallurgical photographs shall be furnished expeditiously to Grumman for review and approval.

3. Finalized terminal design drawings and cover drawings shall be furnished quickly to Grumman for information.

4. The Quality Assurance Specification for the manufacture of ceramic-to-metal seals, E.P.-MS-122 and comments listed in Grumman AVO D559-1-33, dated 12/7/71, shall be reviewed quickly for specified terminal material and dimensional changes. These changes shall be immediately transmitted to Grumman for approval. Thenceforward, this specification must be enforced and copies of all test data and material certifications for all life cell terminals must be furnished to Grumman for information (none of these data were furnished to Grumman on the parametric cells).

Compliance with these requirements will avoid the leak problems found in the parametric test groups. It will further obviate the necessity to spend valuable test preparation time to reseal cells. Finally, any danger of carbonate contamination from the atmosphere due to excessive leakage will be eliminated.

AVOID VERBAL ORDERS

APPENDIX K-5

FROM	S. Gaston	POD/553	35	X9142	DATE 17 January 1973
	NAME	GROUP NO. & NAME	PLANT NO.	EXT.	NO. D559-2-39 (Addendum)

TO: J. Rogers, LM Subcontracts

SUBJECT: 100 A.H. BATTERY DEVELOPMENT PROGRAM - DISTRIBUTION OF CELL TERMINAL PHOTOMICROGRAPHS AND X-RAYS

REFERENCE:
(a) Contract NAS 9-11074
(b) Grumman P.O. #015161
(c) Grumman AVO D559-2-39, dated 12/27/72

ENCLOSURE: (Dist. to parties designated by * only)
1) Composite Photomicrograph Picture of "Butt Seal" Terminal Analysis
2) Pictures of Terminal Radiographs

The above reference (c) AVO indicated photomicrographs of the metallurgical analysis findings would be published as soon as copies were available. Enclosure 1) to this addendum is a composite of these results. Discussion of this material is found in the AVO.

In addition, a radiographic examination for braze voids was conducted on the second terminal of the cover sample. Enclosure 2) (top photograph) contains top and angular views. The top view shows two (2) gray areas (voids). The angular view shows that these voids are located in the top cup seal. The bottom picture consists of additional angular views. Standard x-ray techniques were applied to obtain these views (125 KV, 4 ma., 2 minutes, "B" Monopack GAF, Class 1, lead).

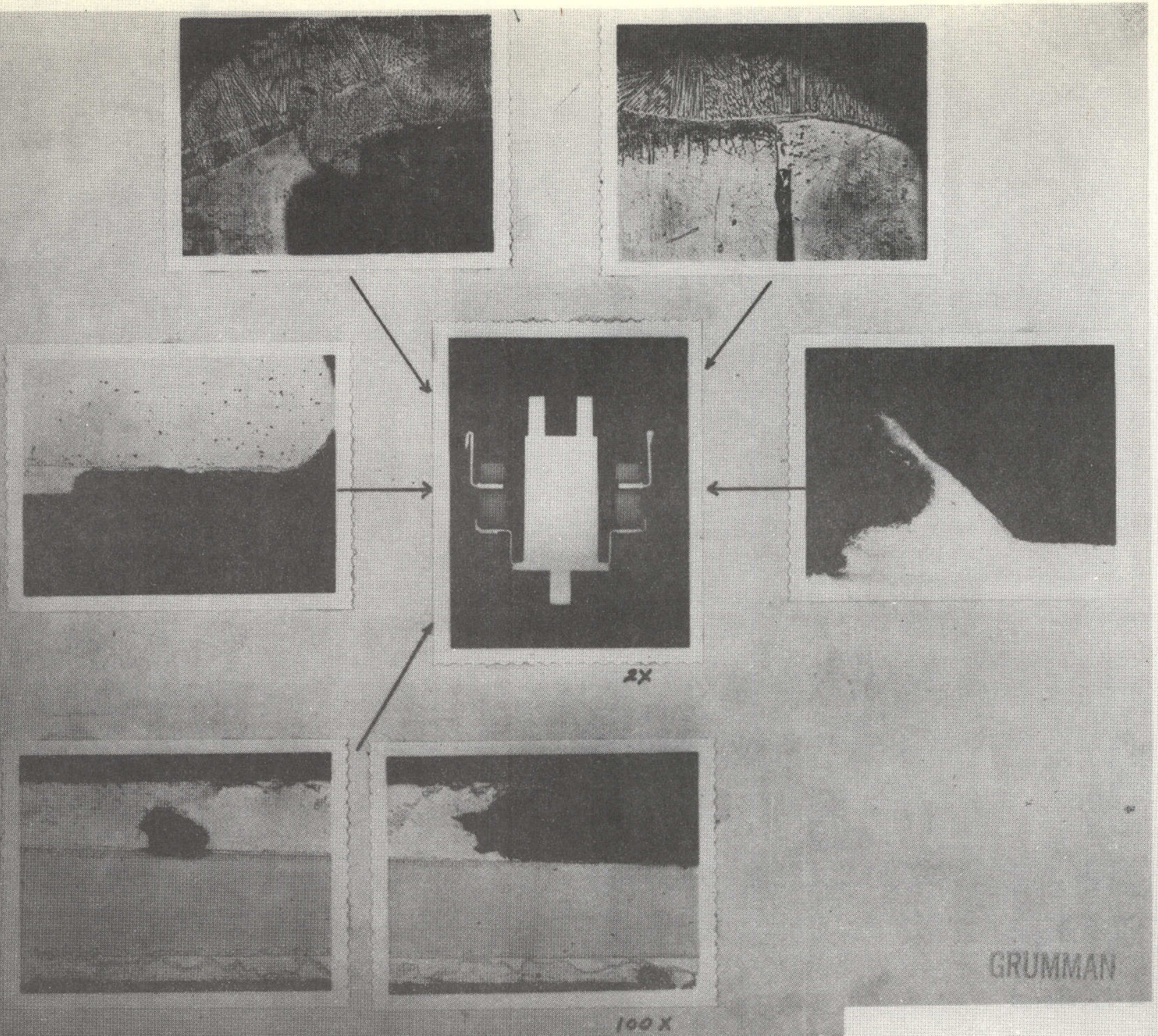
Based on these radiographs, it appears that void areas in the braze can be detected with this non-destructive technique. It seems better to make x-rays prior to the terminal-to-cover weld operation. Also, this technique can be more cost effective if a number of terminals are radiographed at the same time.

Eagle-Picher is hereby requested to review and comment on this braze void examination technique with respect to incorporation in the process requirements for life test cell terminals. This radiographic examination is not intended to replace established metallurgical sampling, but to provide additional quality assurance on a sample basis for all units. Maximum void size and maximum number of permissible voids (i.e., acceptance/rejection criteria) still need to be established.

SG/gms

INFO CC:

E. Carr, Eagle-Picher*
J. Cioni, NASA/Houston*
F. Ford, NASA/GSFC*
E. Miller
T. Hine
M. Wertheim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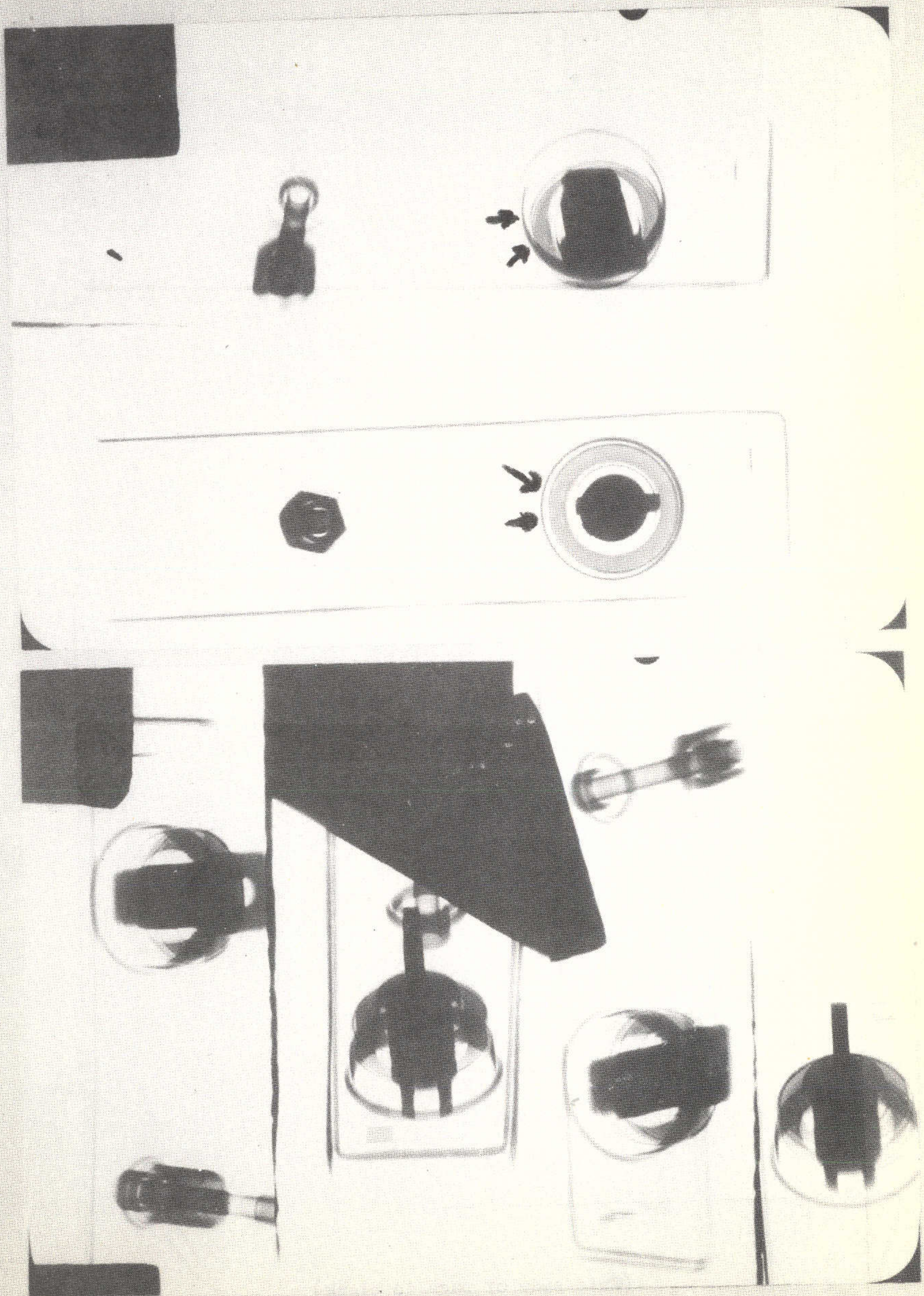

ATTACHMENT 1 TO APRIL 1971 MONTHLY PROGRESS REPORT

AUXILIARY ELECTRODE DESIGN AND PERFORMANCE INVESTIGATION

1. BACKGROUND

Once sufficient data was available on cell development group 1 from Eagle-Picher, an evaluation of auxiliary electrode performance showed results quite different than those anticipated. The high residual (0 psia) voltage, and low signal-to-level ratio make utilization of this design to provide charge control too complex and expensive to consider seriously. The further complications of large temperature coefficients of signal and level, and their variability from cell to cell, reduces the possibility of successful implementation with detection and control circuits.(Actual figures are quoted in the main body of this report).

It was also found that actual values of load resistance for maximum power showed variabilities as high as 2:1 from cell-to-cell, with oxygen pressure, and with temperature. If maximum power operation were desirable, no two detector circuits could be designed alike, and there would be a major question regarding repeatability for any cell versus life.

Hughes Aircraft, in their latest report for Air Force contract F33615-70-C-1710, reported similar problems with auxiliary electrode operation for 50 Amp-Hr. cells. (See pp 2 and 3 of March 1971 Progress Report, Hughes Aircraft.) Accordingly they have dropped any notion of using auxiliary electrode charge control, and will attempt instead to use pressure transducers. Grumman believes a better alternative is achievement of greater understanding of auxiliary electrode design and performance criteria and interactions.

A study was thus started along these lines, and significant facts are already emerging.

2. AVAILABLE LITERATURE

Literature on hand at Grumman was searched for any pertinent information. Two documents presently form the basis for continuing effort:

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1. Final Report; January 1968; "Characterization of Recombination and Control Electrodes for Spacecraft Nickel-Cadmium Cells"; Carson, Rampel, Weinstock; NASA/GSFC contract number NAS 5-10261.

2. Report; June 1970; "Summary Report on Nickel-Cadmium Batteries for Apollo Telescope Mount"; Kirsch, Shikoh; NASA/MSFC contract number NAS 8-20055.

From the first item above, three basic relationships were acquired which, subject to experimental verification, appear to be fruitful in describing the performance-design interrelationships of auxiliary electrodes. These are as follows:

1. <u>Oxygen Diffusion Rate</u> (r_{02})

$$r_{02} = \frac{kA}{d}(P-Po) \text{ moles/second} \qquad (1)$$

k: diffusion constant for the electrode barrier material and the active gas (O_2) -- mole-cm/gm-sec.

A: active area of the auxiliary electrode -- cm^2

d: barrier layer depth -- cm

P: pressure at gas-facing side of barrier -- gm/cm^2

P_o: pressure at electrode side of barrier -- gm/cm^2

The relationship describes, then, the rate at which oxygen will diffuse across (and thus recombine) an active electrode as a function of the barrier layer material, and the geometry of the electrode. If the electrode is operated in a current-limited mode; i.e.: a counter-electrode (the cadmium negative) is used as a voltage source; $P_c \ll P$, and (1) simplifies to:

$$r_{02} = \frac{kA}{d} P \text{ moles/second} \qquad (2)$$

P, of course, is now defined as net average free oxygen pressure in the cell in gm/cm^2.

2. <u>Limiting Current</u> (i_c)

$$i_c = nFr_{02}$$

$$= \frac{knF\ AP}{d} \text{ amperes} \qquad (3)$$

n: gram equivalent of oxygen - 4 equiv/mole

F: Faraday's constant = 96,484 coulomb/equiv.

(The report from which this is taken, p. 8, mis-defines "n", however this has no bearing on the accuracy of the relationship, which is a standard one.)

3. <u>External Circuit Voltage</u> (iR)

$$iR = E - \frac{R_oT}{nF} \ln\left(\frac{i}{i_o}\right) - \frac{R_oT}{nF} \ln\left(\frac{i_c}{i_c - i}\right) - ir \qquad (4)$$

E: Auxiliary - negative electrode couple voltage with no load resistor (open-circuit), and no oxygen pressure -- volts

R_o: Gas constant = 8.314 Joules/mole-^oK

i: External circuit current -- amperes

T: Absolute temperature of cell -- ^oK

i_o: Carrier displacement current at barrier layer

R: External load resistor between auxiliary and negative electrodes -- ohms

r: Internal resistance of the couple under load, and with positive free oxygen pressure -- ohms

The i_o factor expresses the capability of free oxygen to acquire excess electrons beyond its valence (reduction); and is thus very small compared to either i_c or i. (Theoretically, at the auxiliary electrode, $i_c = i_o + i$.)

(4) can then be simplified to:

$$iR = E - \frac{R_oT}{nF} \ln\left(\frac{i_c i}{i_c - i}\right) - ir \qquad (5)$$

which is the <u>practical</u> operating relationship of the auxiliary-negative electrode couple.

Several points can be derived immediately from (5):

1.<u>E</u> -- is an inherent voltage number relating to the specific design of the couple. The value is thus a function of material, barrier depth, geometry, and, probably, auxiliary electrode location.

2.<u>r</u>-- is a dynamic quantity present <u>only</u> when the couple is loaded, and free oxygen occurs. Solving (5) for E also shows that r is a <u>negative</u> quantity, which is demonstrated by Figures 34 through 37 of the NASA/MSFC report.

3. R+r -- when this algebraic sum is a minimum, maximum load power occurs. However, due to the presence of T in the log term, this is <u>also</u> the region where the signal is <u>most</u> temperature sensitive.

A study of the above relationships, and Figures 34 through 37 of the NASA/MSFC report also permits certain inferences to be drawn:

1. r -- The curves referred to above have several points of inflection at various load resistances, and are not the same shape at each constant pressure depicted. Thus a plot of power versus load resistance at constant pressure will show more than one peak point. There will probably be one peak higher than the others (representing R + r = 0). (When the data of the NASA/GSFC report is carefully plotted, and intermediate load resistance values computed, this is indeed the case, and R + r = 0 at R= 180 Ω and T = 10°C.) r seems to be a function of pressure, external load and, probably, limit current or E. The last item would determine the range of r as a function of electrode design parameters.

2. Design parameters of the auxiliary electrode are sensitive to the ampere-hour rating of the cell. For example, i_c and electrode area are inter-related, leading to the tentative conclusion (supported by (1), (2) and (3)) that available volume and/or mass of free oxygen to achieve a specific pressure determine the way the electrode is constructed. Here it must be understood that, while current density is a direct pressure function, <u>total</u> current is an integrated quantity determined by recombination (diffusion) rate, r_o. Thus, one can say that if more oxygen is present than can be diffused, too-small an electrode will quickly saturate (reach a limiting current <u>density</u>), and will thus become insensitive at relatively low pressures.

3. If 1. and 2. above are true, the problems encountered with group 1 cells probably fall into two categories:

   a) Improper operating point

   b) Undersized and, perhaps, mislocated electrode.

The first would be at least partially traceable to the second, and would partly account for the extremely low signal level and the apparent drift of "maximum power" load with pressure and temperature. The second would cause the very high 0 psia residual levels, and would also affect both signal quantity and data stability.

3. TEST PROGRAM

In order to verify the above-noted conclusions, refine the inferences, and achieve greater understanding of the interrelationships among the basic parameters, Grumman is conducting a test program. The program is designed to yield results at small increments of load resistance (for the auxiliary electrode circuit) and oxygen pressure. The program will be conducted on at least two sizes and types of cell at first:

a) Gulton 20 Amp-Hr. from the OAO project.

b) Eagle-Picher 100 Amp-Hr. borrowed from NASA/GSFC.

There are two cells of each type, each equipped with an auxiliary electrode and a pressure gauge. (The gauge will be installed on the 100 Amp-Hr. units by Grumman personnel in a glove box.)

The test program is as follows:

1. Conditions: $R_{3\ LOAD} = 47\Omega$ (from OAO data)

   Monitor V_{CELL}, V_3, T_{CELL}, T_{AMB}, P for all tests.

2. Condition cell at $T_{AMB} = 20^{\circ}C$

3. Capacity test to 0.90 V at C/2 rate, $T_{AMB} = 20^{\circ}C$

4. Auxiliary Electrode Test; $T_{AMB} = 20^{\circ}C$:

   a) Start at end of capacity discharge

   b) In addition to parameters noted above, monitor I_{CHG}, I_{DISCH}, NUMBER OF CHG/DISCH. CYCLES

   c) Start charge at C/10 $\pm 2\%$

   d) Maintain constant current charge until $V_{CELL} = 1.45$ V, then switch to constant voltage mode.

e) Charge in accordance with c) and d) above until 60% of the ampere-hours found in 3. above have been returned, and/or that oxygen pressure has not climbed from the 0 psia level(i.e.: the residual following the capacity test)

f) Measure V_3 for the following $R_{3\ LOADS}$:

1. $1.0\Omega < R_{3LOAD} < 100\Omega$ at 5Ω intervals
2. $100\Omega < R_{3LOAD} < 1000\Omega$ at 20Ω intervals
3. Open circuit

The resistors to be used for these measurements shall be pre-calibrated, and actual values shall be recorded for each. Each resistor shall be within $\pm 5\%$ of desired value.

g) Charging shall then be continued until $P_{02} = 3.0 \pm 0.5$ PSIA, and test (f) above shall be repeated.

h) Steps (g) and (f) shall be repeated every 3.0 ± 0.5 PSIA through $P_{02} = 45$ PSIA

i) The cell shall then be discharged at C/10 $\pm 2\%$ rate, and steps (g) and (f) shall be repeated every 3.0 ± 0.5 PSIA down from 34 PSIA to 0 PSIA with final data to be taken at 0 PSIA.

j) Should pressure stability prove to be poor, steps (f) through (i) shall be performed by holding $R_{3\ LOAD}$ at each desired fixed value and reading V_3 at each pressure point called for above while cycling the cell through charge and discharge. In this case, current rates may be altered to achieve more test efficiency, but the changed rates shall be noted as part of test data.

k) Repeat $R_{3\ LOAD}$ calibration at end of test.

l) Repeat steps (a) through (k) at $T_{AMB} = 0°C$, except calibrate $R_{3\ LOAD}$ at end of test.

m) Repeat steps (a) through (k) at $T_{AMB} = 10°C$, except calibrate $R_{3\ LOAD}$ at end of test

5. Repeat test 3.above following auxiliary electrode test and full charge.

In addition to the above program, Eagle-Picher is conducting parallel, independent test and study effort as part of its obligation to Grumman. This is discussed briefly in Attachment 3. (See Appendix L-2).

APPENDIX L-2

EXCERPT FROM ATTACHMENT 3 TO

APRIL 1971 MONTHLY PROGRESS REPORT

TECHNICAL MEETING BETWEEN EAGLE-PICHER & GRUMMAN ON 4/23/71 AT GRUMMAN

AUXILIARY ELECTRODE PERFORMANCE - The discussion now reverted to auxiliary electrode response. Messrs Gaston and Wertheim pointed out that, although Hughes was pleased with the performance of EP's auxiliary electrode compared to that of GE and Gulton, overall Hughes felt none of the manufacturers had supplied cells which would easily lend themselves to charge control by this me method. It was also noted that, based on the group 1 data, Grumman had come to the same conclusion, but that, unlike Hughes, we were not yet ready to give up on the technique. Mr. Wertheim then presented the information contained in Attachment 1 of this report as a vehicle for further discussion, asking EP for their feelings and opinions on the matter.

Messrs Carr and Harsch responded as follows:

a) Hughes is using a 47Ω load resistor in their auxiliary electrode circuit. (Mr. Wertheim pointed out that this would change the values, but not alter the basic problem.)

b) On the question of loaning cells to Grumman for testing, EP felt that NASA/GSFC's RSN-6B's would be most useful.

c) EP will duplicate some of the tests on their 100 Amp-Hr. cells following the in-house thermal and other tests for this program, and after Grumman has laid out a test program.

(Grumman actually obtained 100 Amp-Hr. cells from NASA/GSFC.)

It was agreed that Grumman would pursue development of the theory and verification testing indicated in Appendix L-1. Eagle-Picher would be kept informed of results obtained, and would comment as necessary. Eagle-Picher, in turn, believed that addition of a separator-type wrap around the electrode would help by increasing wetting of the electrode.

They will test the performance of various auxiliary electrode configurations, and report the results to Grumman as soon as possible. EP's approach will be two pronged:

a) 12 Amp-Hr. cells will have electrodes fabricated with separator wraps.

b) 12 Amp-Hr. cells will have non-teflonated electrodes.

They also are considering changes of electrode size for further testing as well.

APPENDIX L-3

Auxiliary Electrode Tests

Excerpt from Eagle-Picher

Phase I Development Report,

DTR-110, dated 15 July 1971

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7. Combination polypropylene separators do not appear to be useable.

H. Auxiliary Electrode Testing

A group of 18 cells (RSN-36 size) were manufactured with various types of electrodes and electrolyte amounts to evaluate the signal response and the oxygen sensitivity of both the signal type and the recombination type auxiliary electrode.

The following is a description of the cells:

CELL S/N	TYPE ELECTRODE	METHOD OF SEPARATION	ELECTROLYTE AMT.
1224	Recombination		
1225	Type	20 Mesh	
1226	Platinum		All
		All Wrap 1*	23%
1227	Teflon		Core
1228	on	40 Mesh	Weight
1229	Nickel Screen		
1230	Signal		21% Core Wt.
1231	Type	Wrap 1*	21% " "
1232	Teflon		19% " "
1233	Raw Plaque		19% " "
1234			21% Core Wt.
1235	Same as Above	Wrap 2**	21% " "
1236			19% " "
1237			19% " "
1238	Signal		21% Core Wt.
1239	Type	Wrap 1*	21% " "
1240	Uncoated		19% " "
1241	Raw Plaque		19% " "

* Gas spacer between electrode and container.
** No gas spacer, electrode wrapped in nonwoven nylon.

3. The maximum power output for the 20 mesh screen is between .2 and .3 ohms (Figure 17); whereas the maximum power for the 40 mesh is between one (1) and two (2) ohms (Figures 18 and 19).

4. During orbital cycling at 30 and 50% DOD, the 20 mesh screen electrodes had a higher peak voltage at the same pressure (Figures 20 - 22).

b. Signal Electrode

Figures 23 - 28 are the results of the full capacity test on the cell with signal type electrodes. In order to analyze this data, it is necessary to compare cell groups.

1. Figure 23 compared to Figure 24 - The only difference between these two cell groups is the electrolyte amount. The cells with less electrolyte show a higher peak electrode voltage and greater oxygen sensitivity in the lower pressure range. The electrolyte voltage on discharge is about the same. The cells with more electrolyte have higher pressures.

2. Figure 25 compared to Figure 26 - These two cell groups differ only in electrolyte amount. They show the same conditions as the groups above and also a lower electrode voltage on discharge for the cells with less electrolyte.

3. Figure 23 compared to Figure 25 - The difference here is Wrap 1 versus Wrap 2 at a 21% core weight electrolyte level. The only change in characteristics is that the cells with the Wrap 2 have less oxygen sensitivity in the lower pressure range.

4. Figure 24 compared to Figure 26 - These cell groups have

Wrap 1 and Wrap 2 but were activated to 19% of the cell core weight. The Wrap 2 cells show a lower oxygen sensitivity at low pressures and a lower electrode voltage on discharge. The peak voltage is about the same.

5. Figure 23 compared to Figure 27 - This comparison is of the teflonated versus non-teflonated electrode, all with Wrap 1 and 21% electrolyte level. The cells with no teflon have lower signal strengths on charge and discharge.
6. Figure 24 compared to Figure 28 - These cells compare the teflonated-nonteflonated electrodes, all with Wrap 1, but at 19% electrolyte level. The oxygen sensitivity and signal strength is much lower for the non-teflonated electrodes. The electrode discharge voltage is also lower.
7. The maximum power output for all the signal electrodes is at less than 1 ohm (Figure 29).
8. Figures 30 and 31 are the signal electrodes with a 1 ohm load resistor. These electrodes show a saturation at about 15 psig.

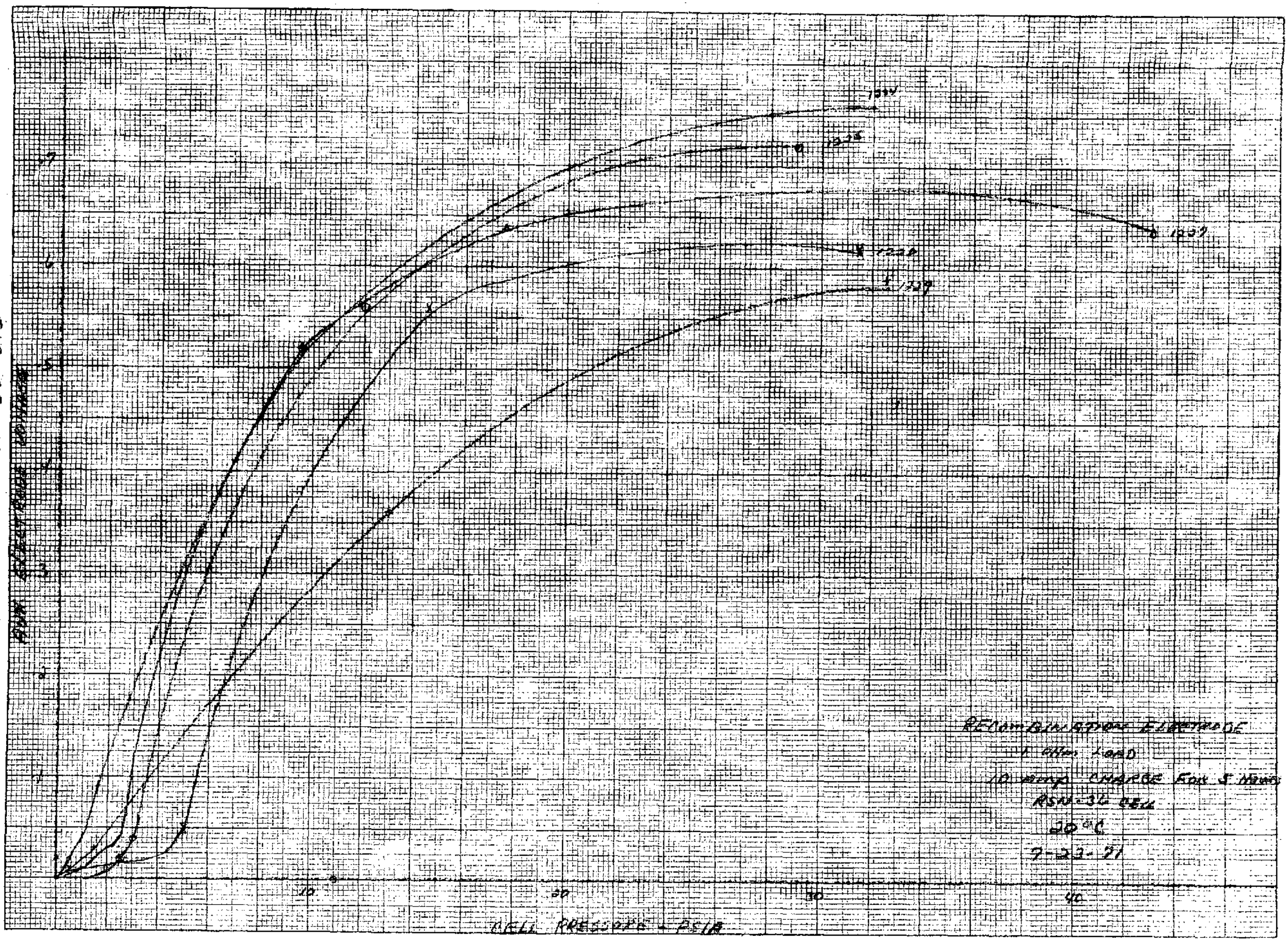
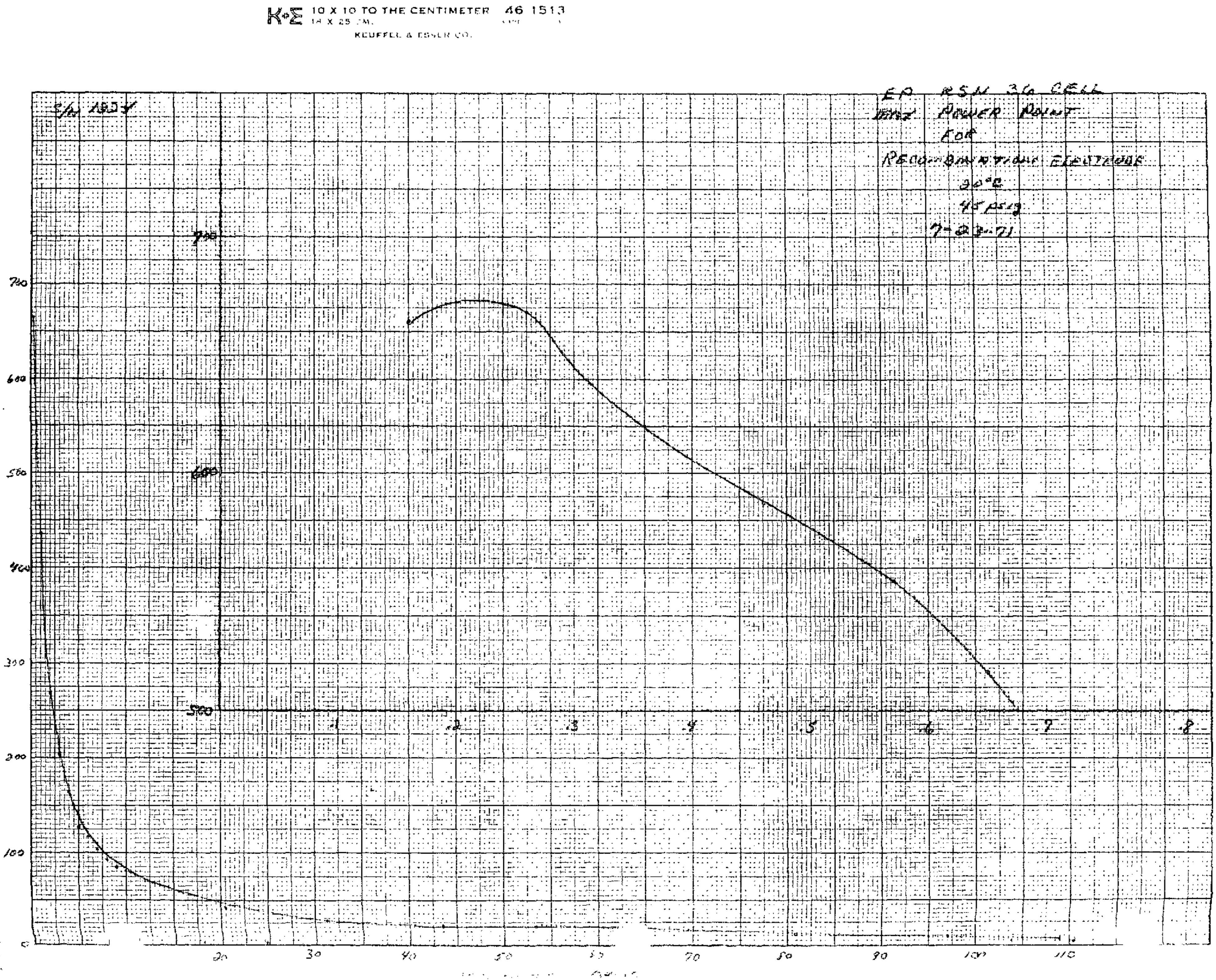
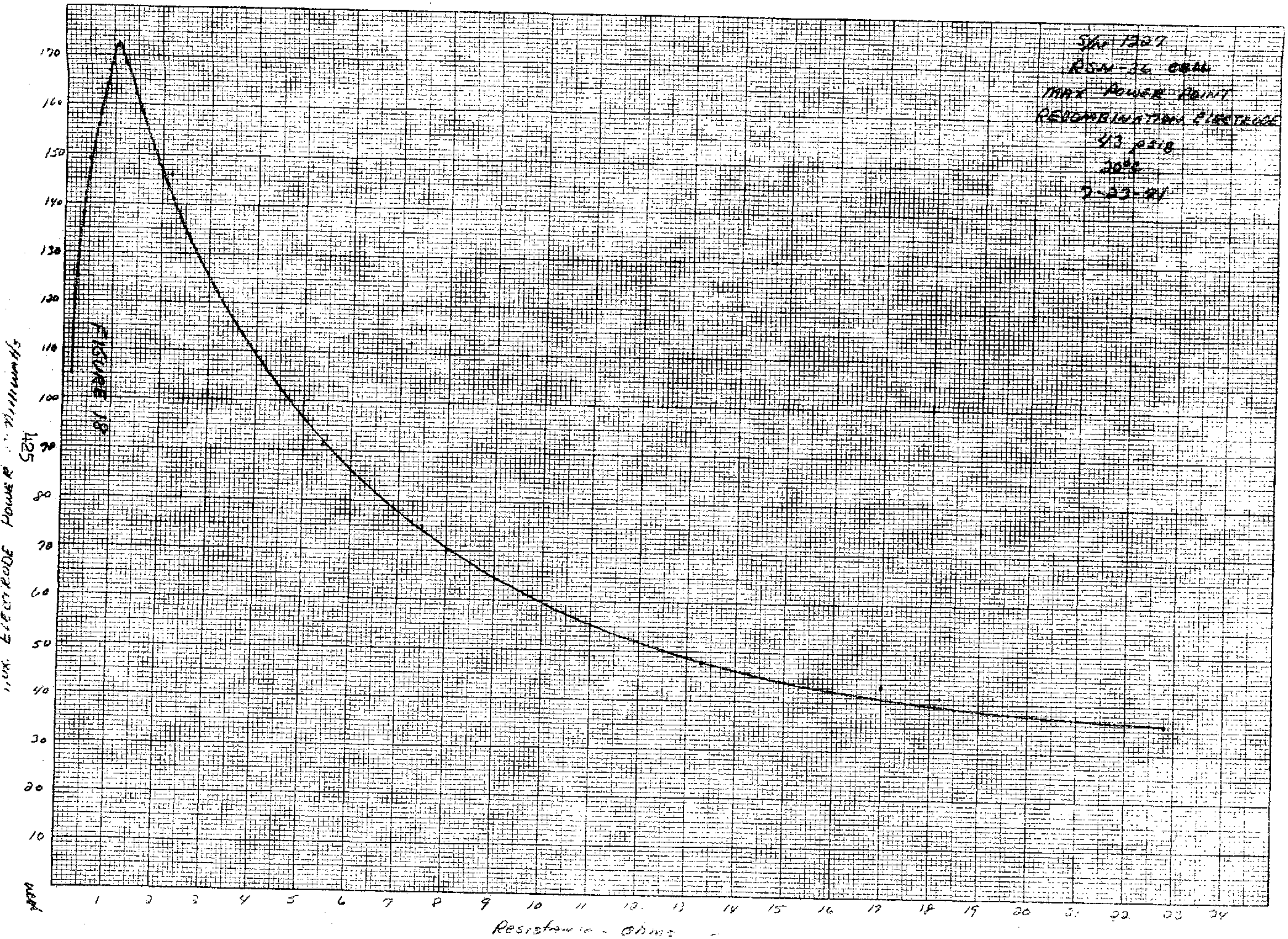

RECOMBINATION ELECTRODE
1 Ohm LOAD
10 Amps CHARGE FOR 5 Hours
RSN-36 CELL
20°C
9-23-71
10
20
30
40
CELL PRESSURE - PSIA

FIGURE 16

FIGURE 17 424




MAX POWER POINT
RECOMBINATION ELECTRODE
43 psig
20°C
FIGURE 18
425
ELECTRODE POWER - Milliwatts
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Resistance - Ohms

K+E 10 X 10 TO THE CENTIMETER 46 1513
KEUFFEL & ESSER CO.

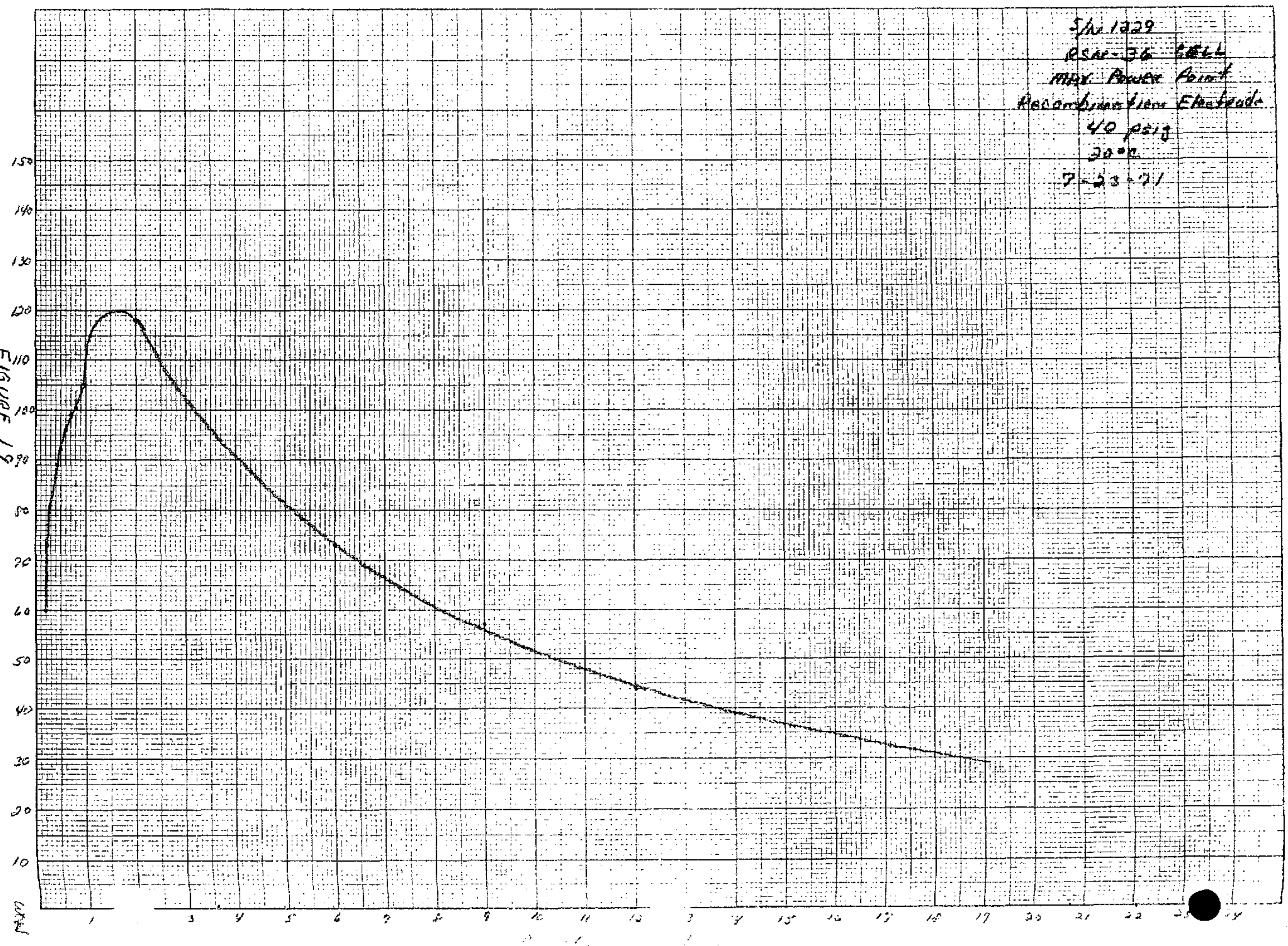


FIGURE 19

K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

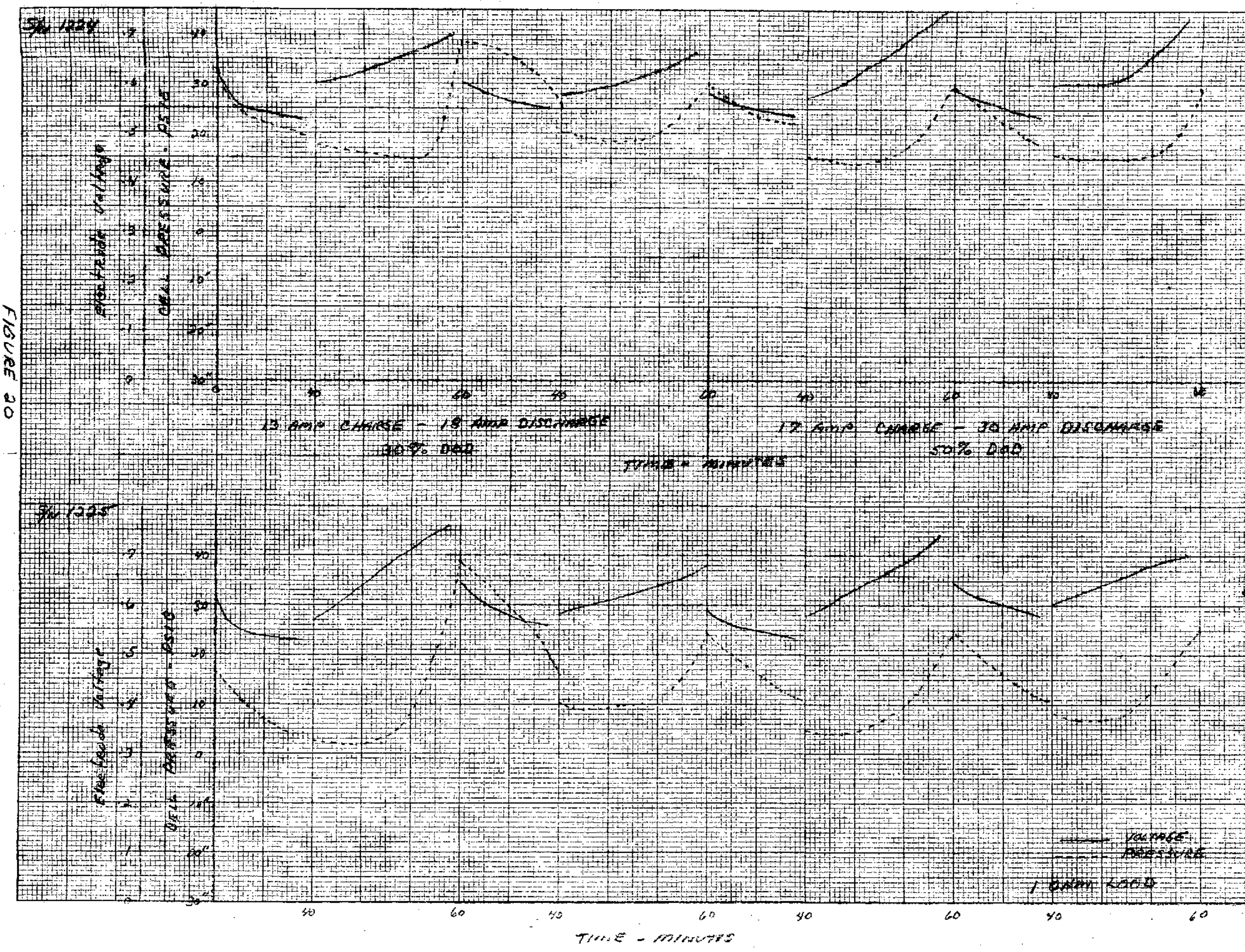
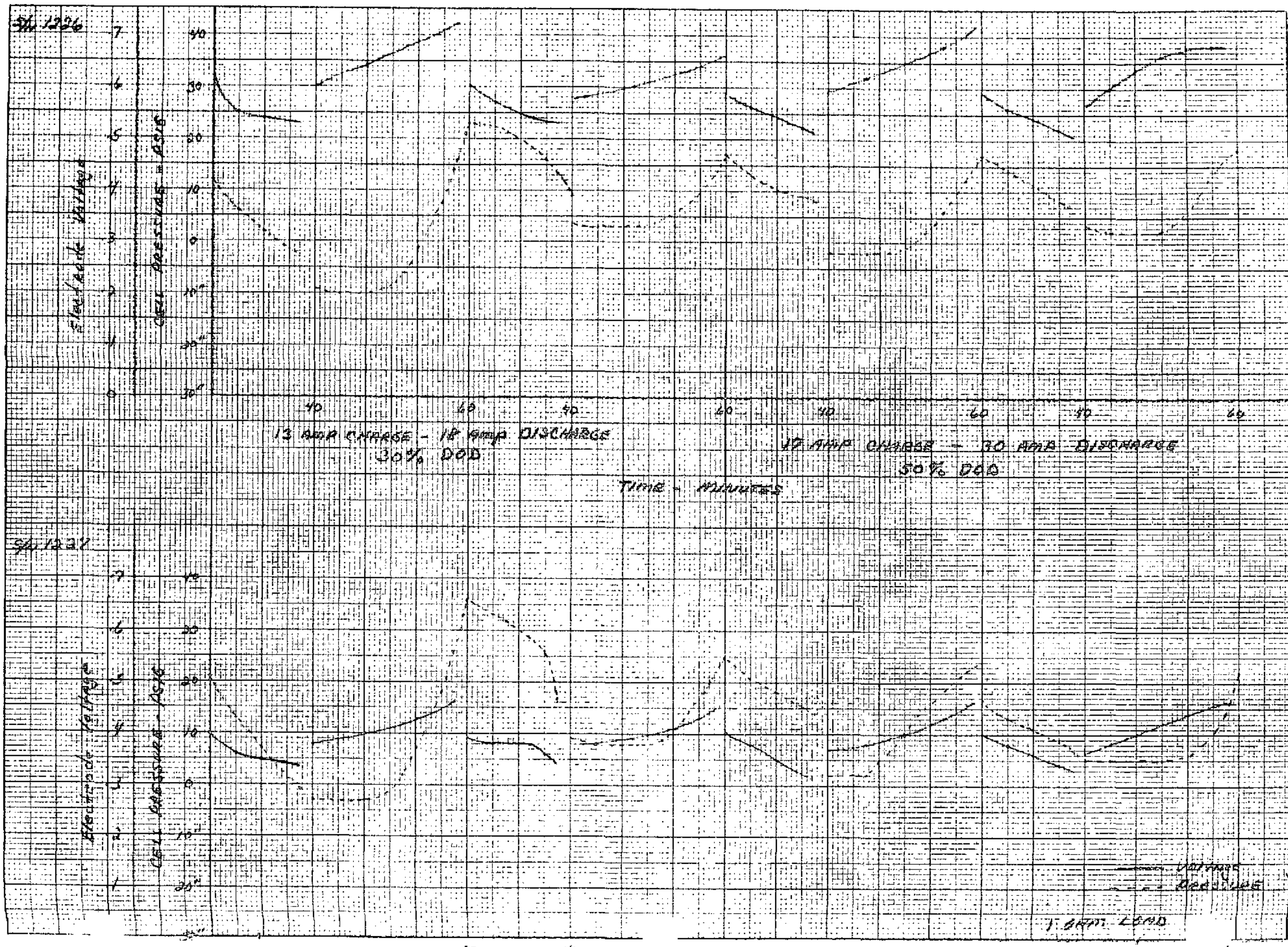


FIGURE 20

RSN-36 RECOMBINATION ELECTRODE - 58 minute Charge - 36 minute Discharge



RSN-36 RECOMBINATION ELECTRODE - 58 MINUTE CHARGE - 36 MINUTE DISCHARGE 30°C

FIGURE 21

428

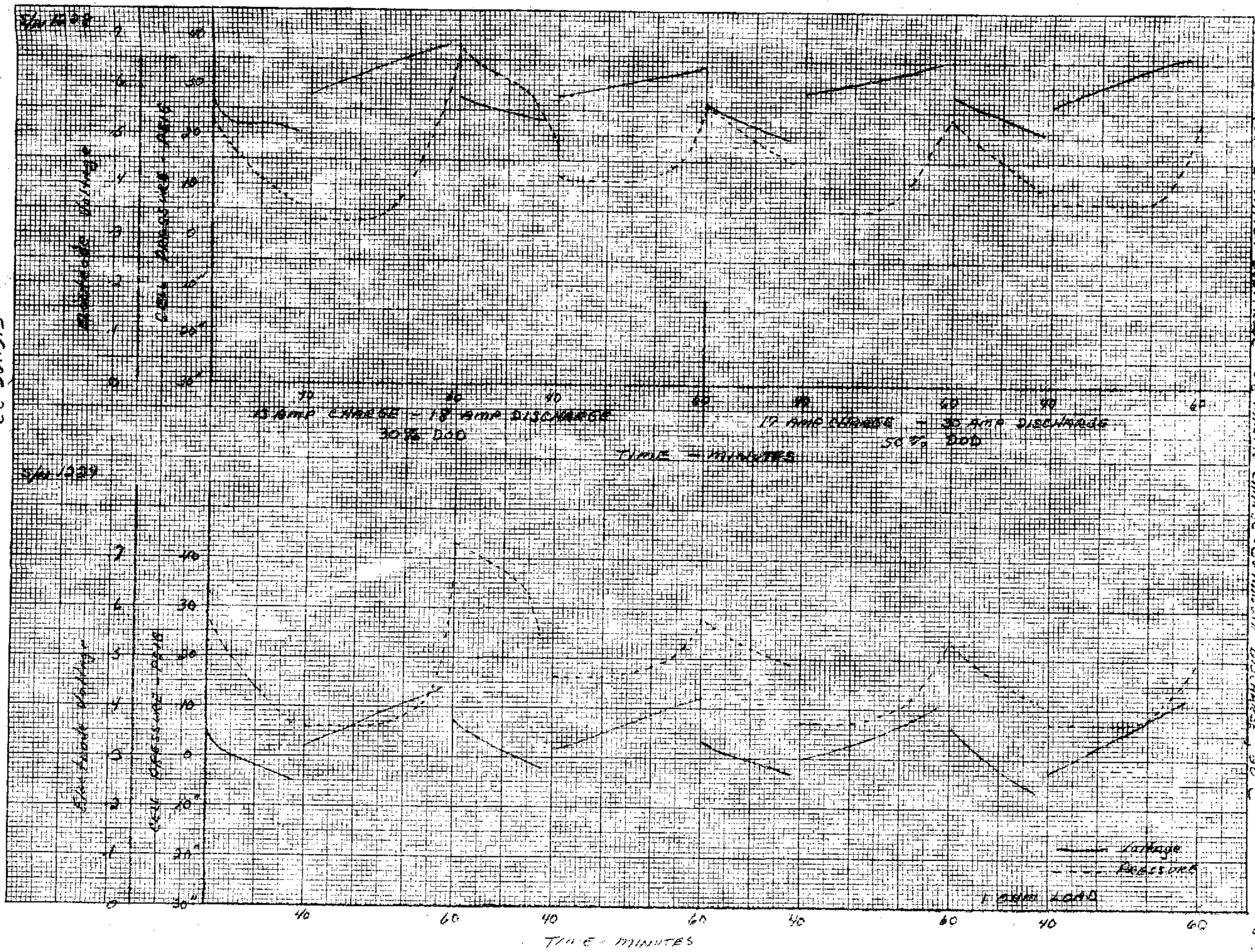
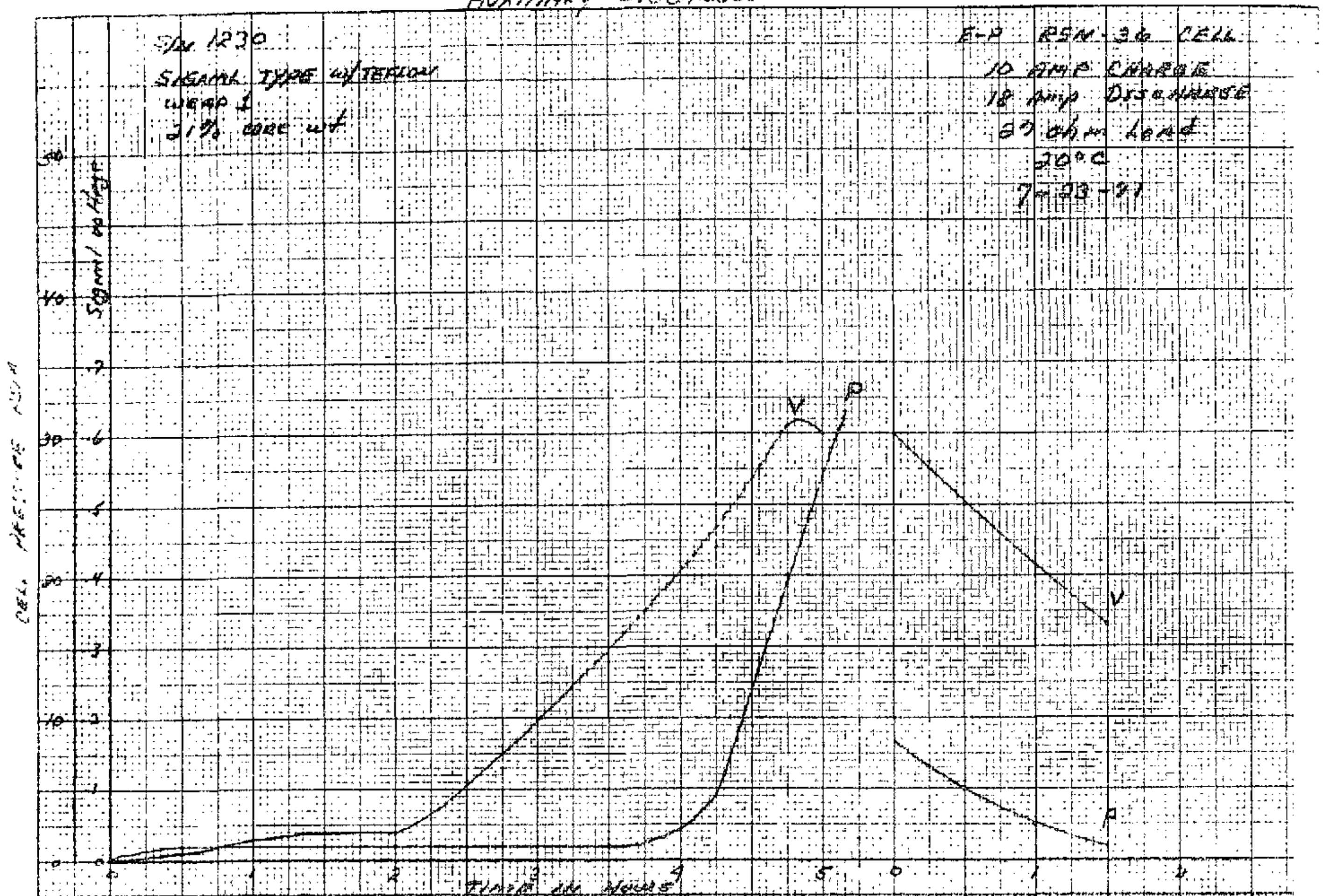
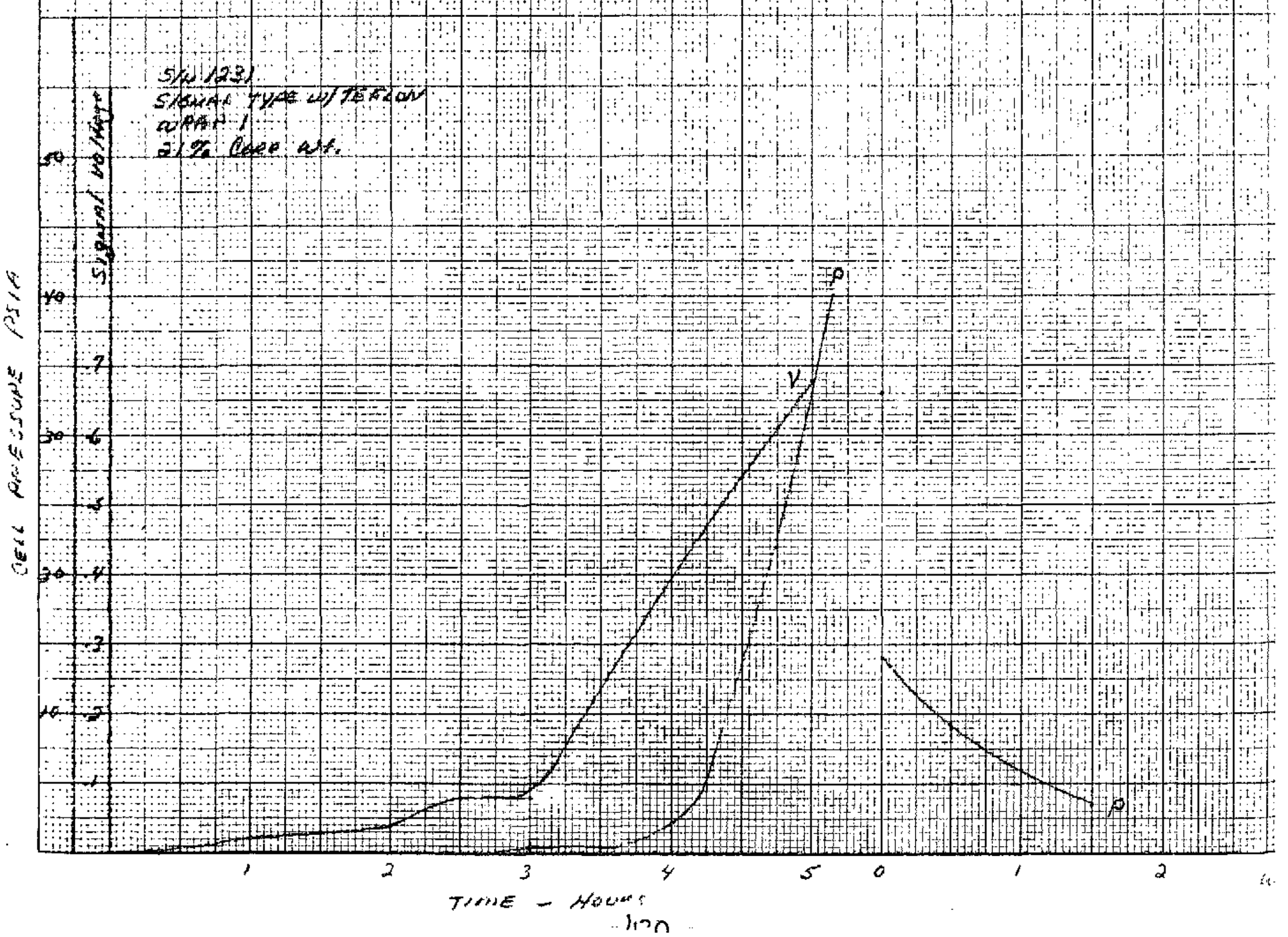

PSW-36 RECOMBINATION ELECTRODE - 58 minute CHARGE - 36 minute DISCHARGE - 30°C
S/N 1228
S/N 1239
15 Amp CHARGE - 18 Amp DISCHARGE
30% DOD
17 Amp CHARGE - 30 Amp DISCHARGE
50% DOD
TIME - MINUTES
Voltage
Pressure
1 OHM LOAD

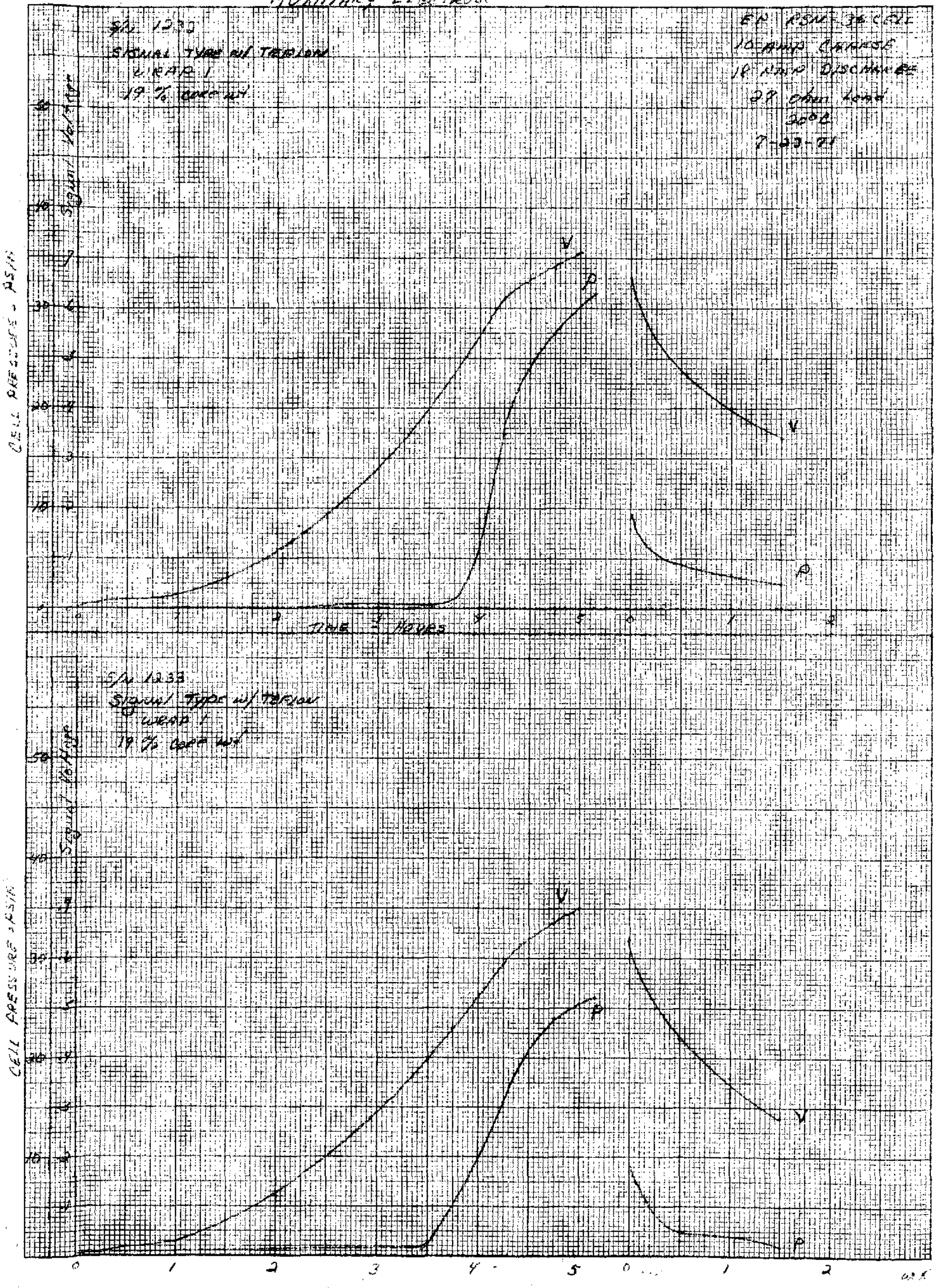
FIGURE 93

Auxiliary Electrode

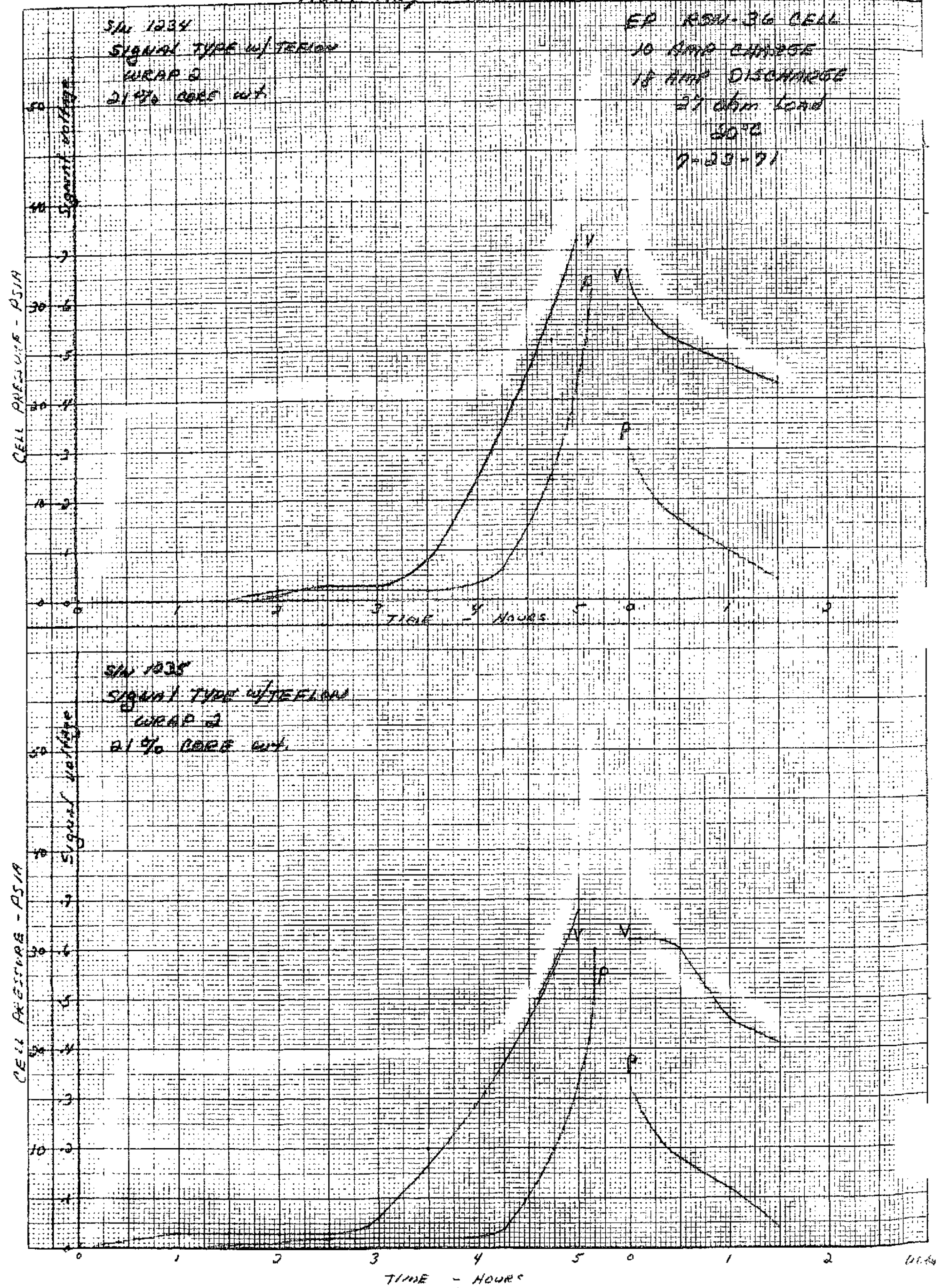




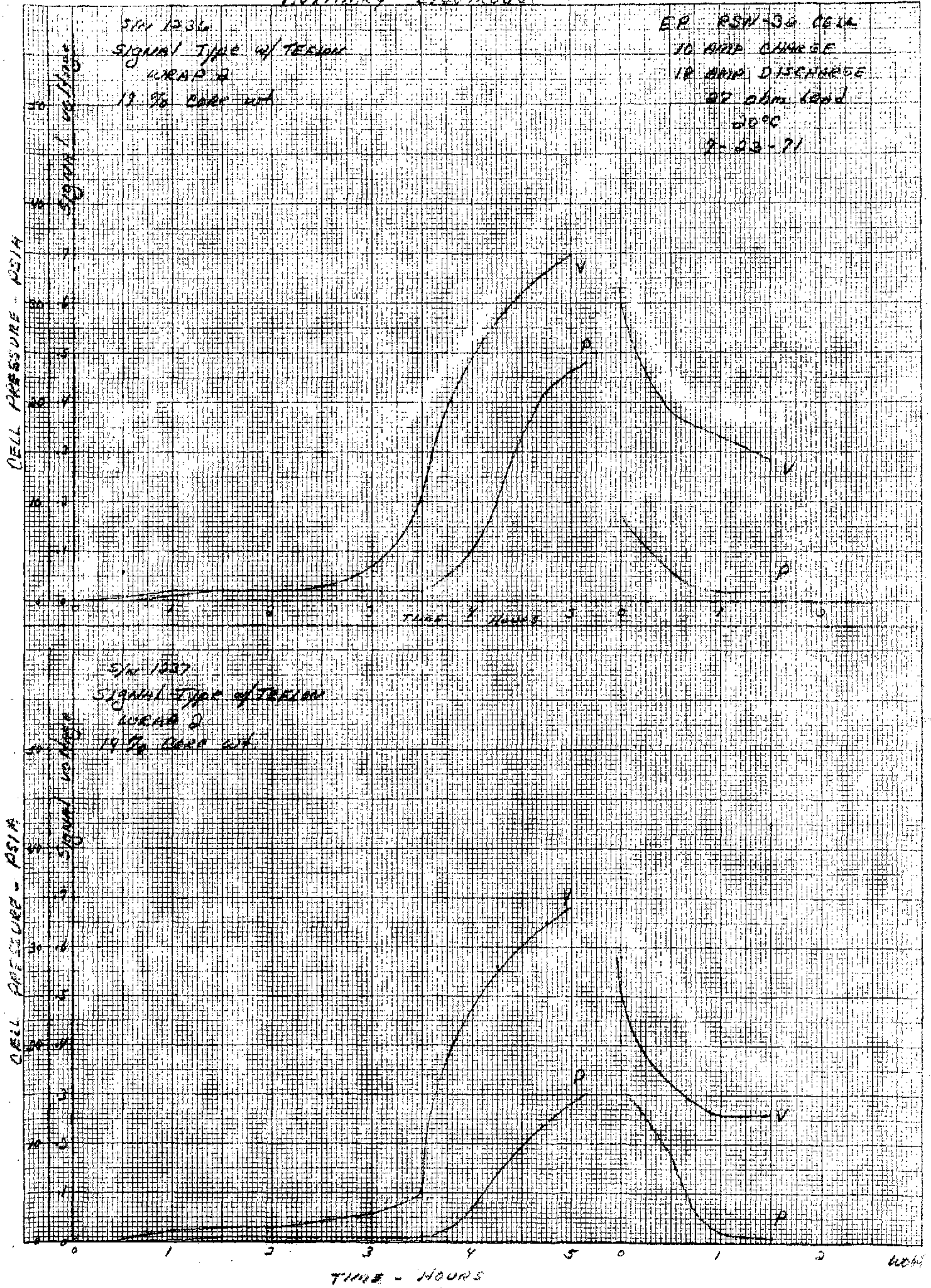
Auxiliary Electrode



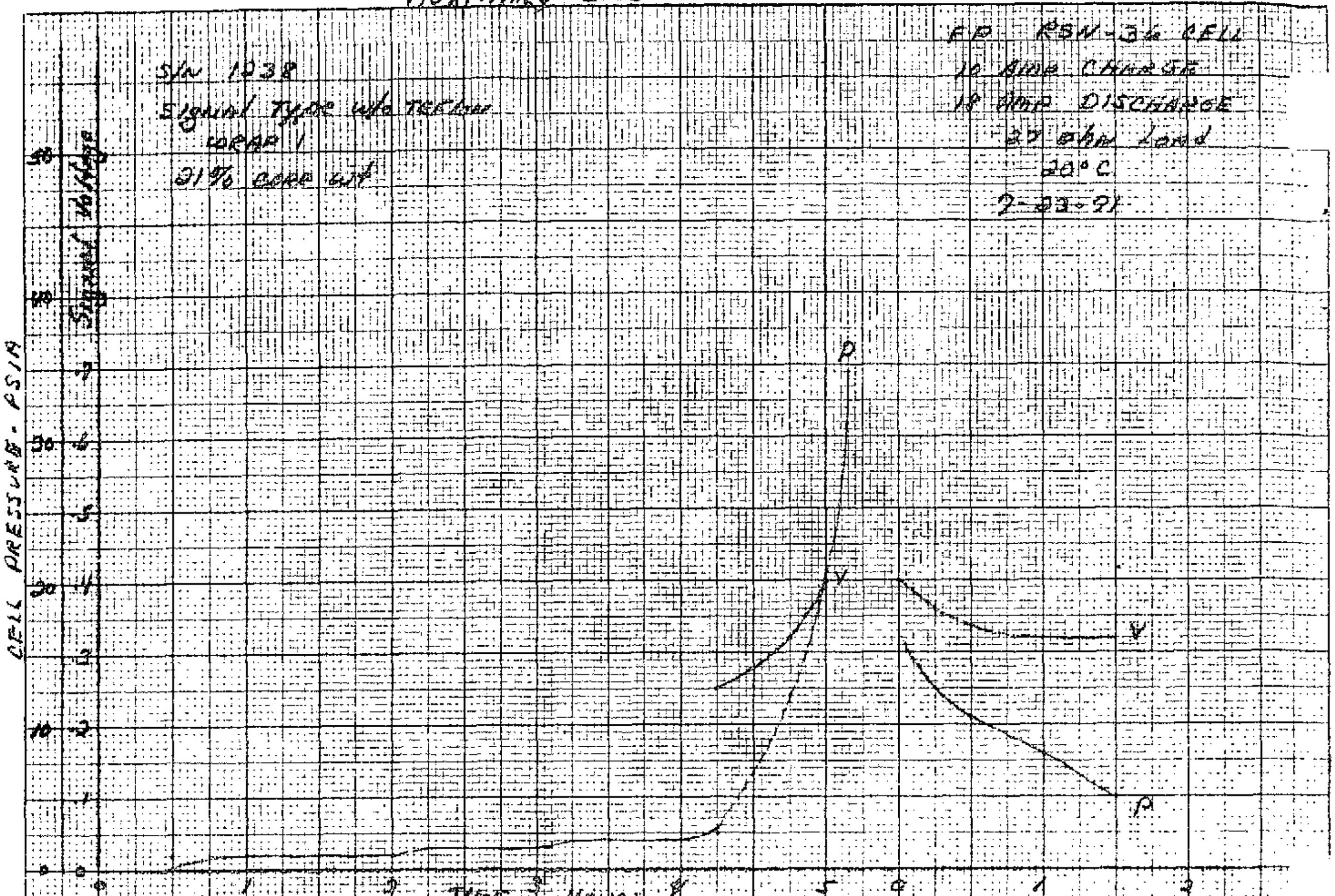
Auxiliary Electrode

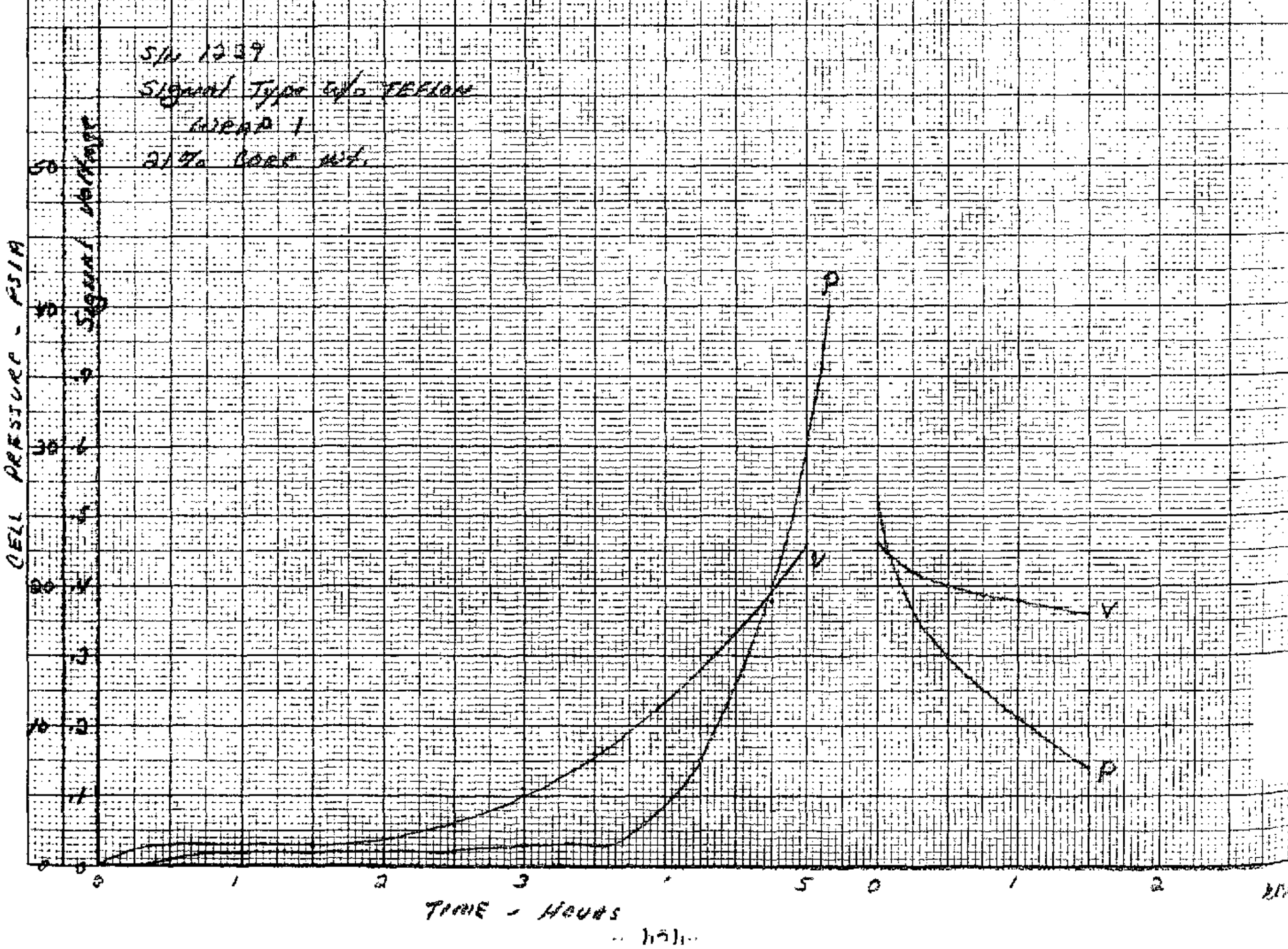


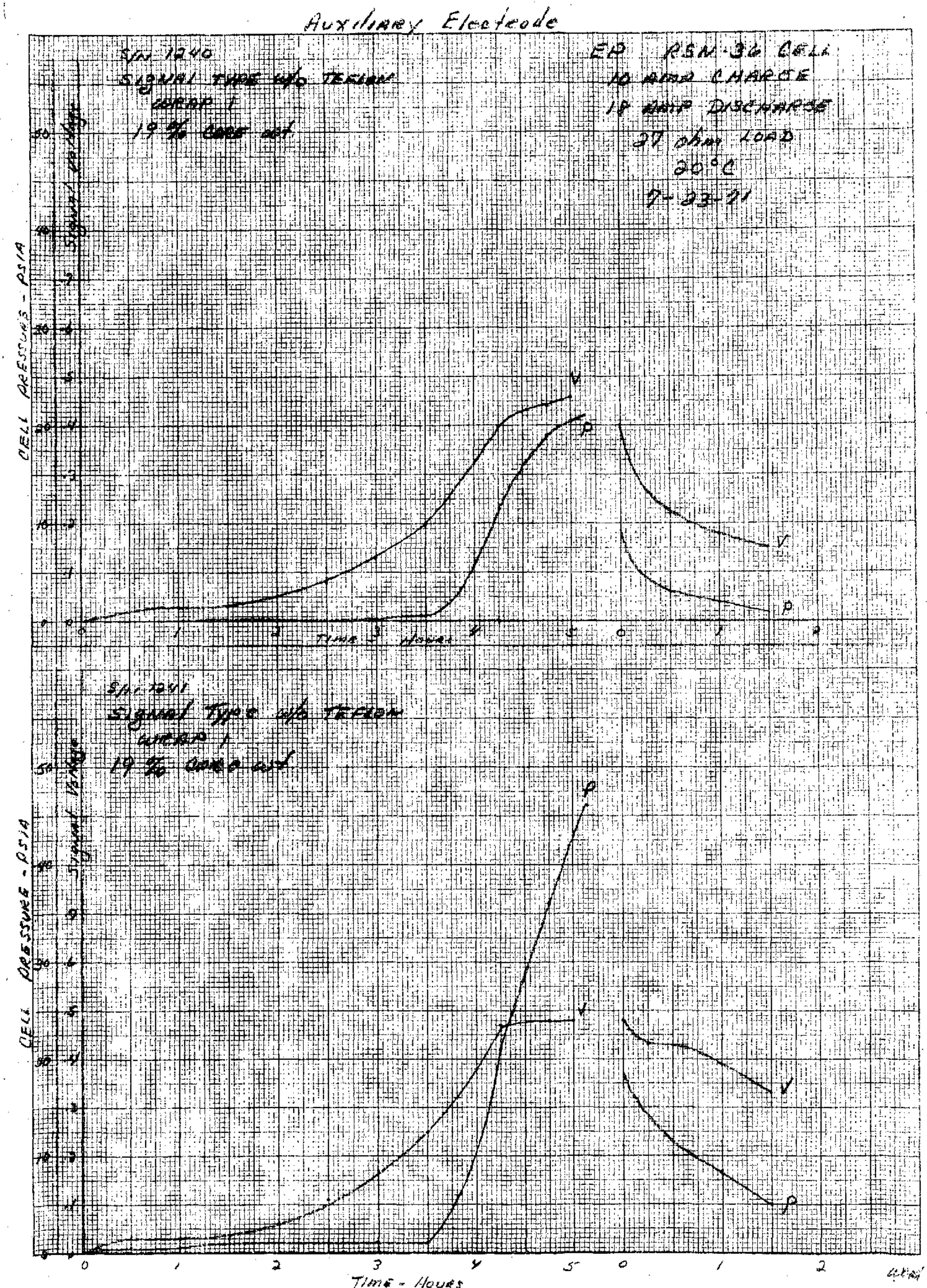
Auxiliary Electrode



Auxiliary Electrode







Auxiliary Electrode
S/N 1240
Signal Type w/o Teflon
Wrap 1
19% Core wt
EP RSM-36 Cell
10 Amp Charge
18 Amp Discharge
27 ohm Load
20°C
7-23-71
Cell Pressure - PSIA
Signal Voltage
Time Hours
S/N 1241
Signal Type w/o Teflon
Wrap 1
19% Core wt
Cell Pressure - PSIA
Signal Voltage
Time - Hours

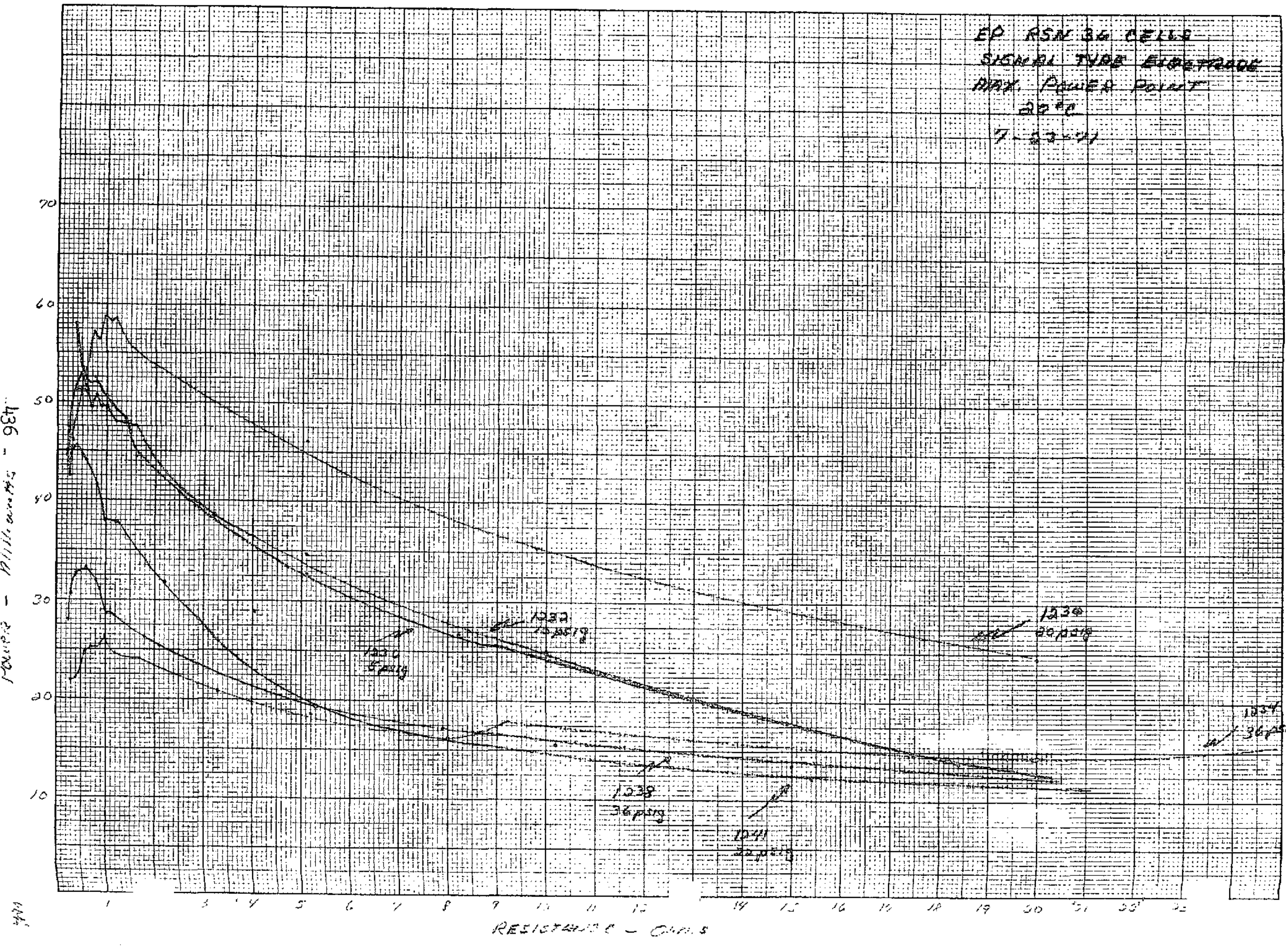
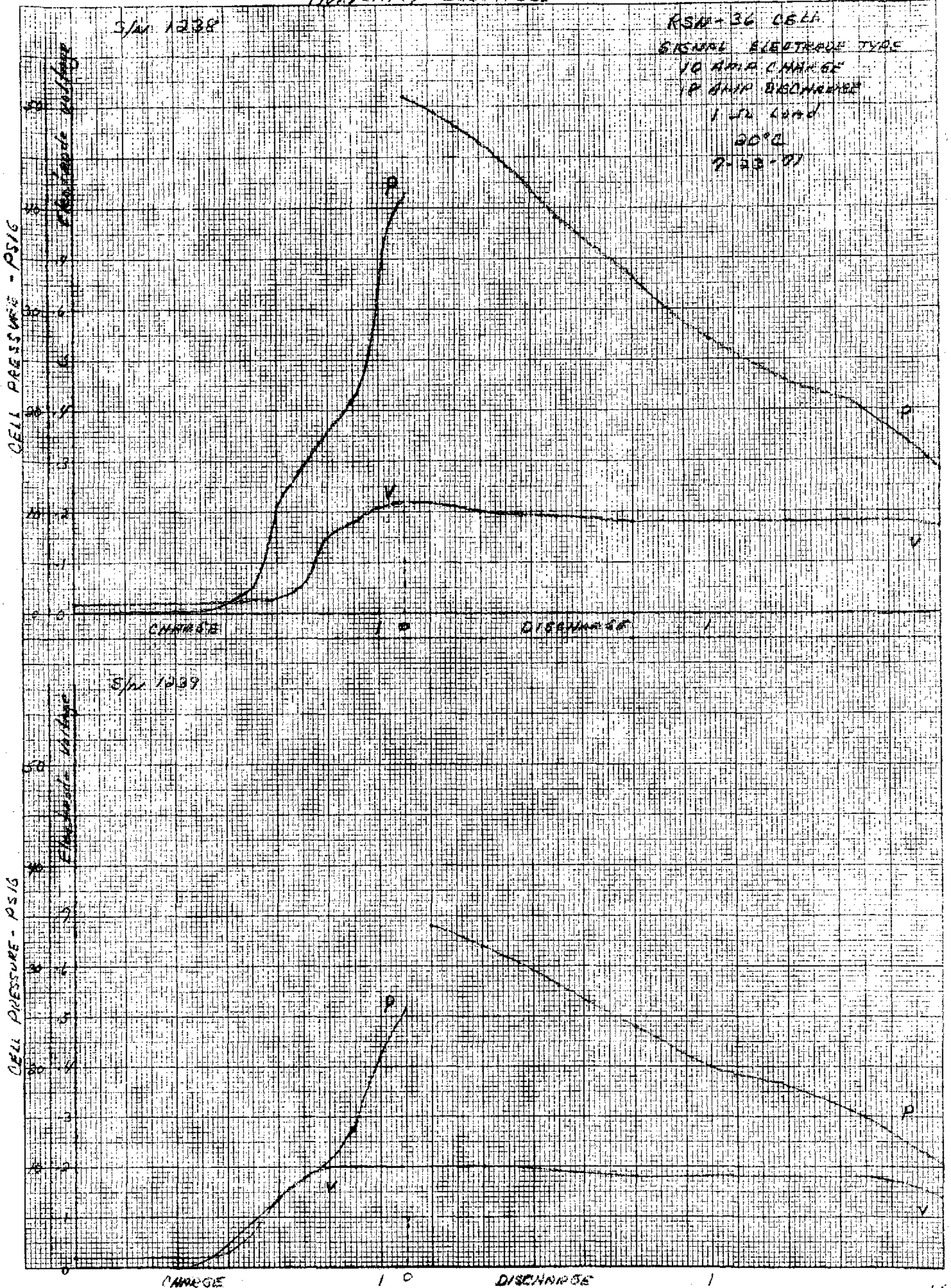

EP RSN 36 CELLS
SIGNAL TYPE ELECTRODE
MAX. POWER POINT
20°C
7-23-71
1232
15 psig
1230
5 psig
1234
20 psig
1237
36 psig
1238
36 psig
1241
20 psig
POWER - Milliwatts
1236
RESISTANCE - OHMS
70
60
50
40
30
20
10

FIGURE 37

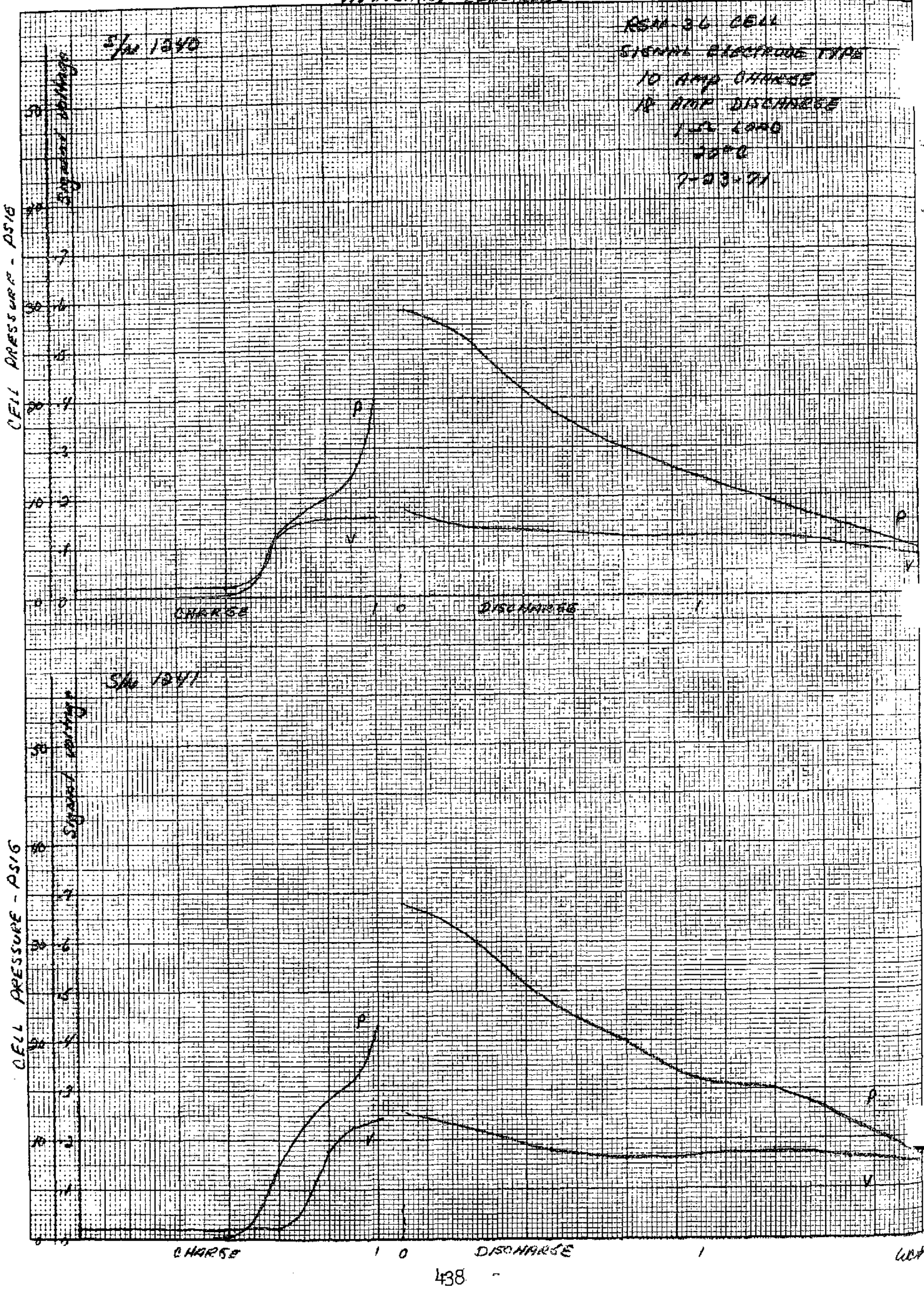
AUXILIARY ELECTRODE

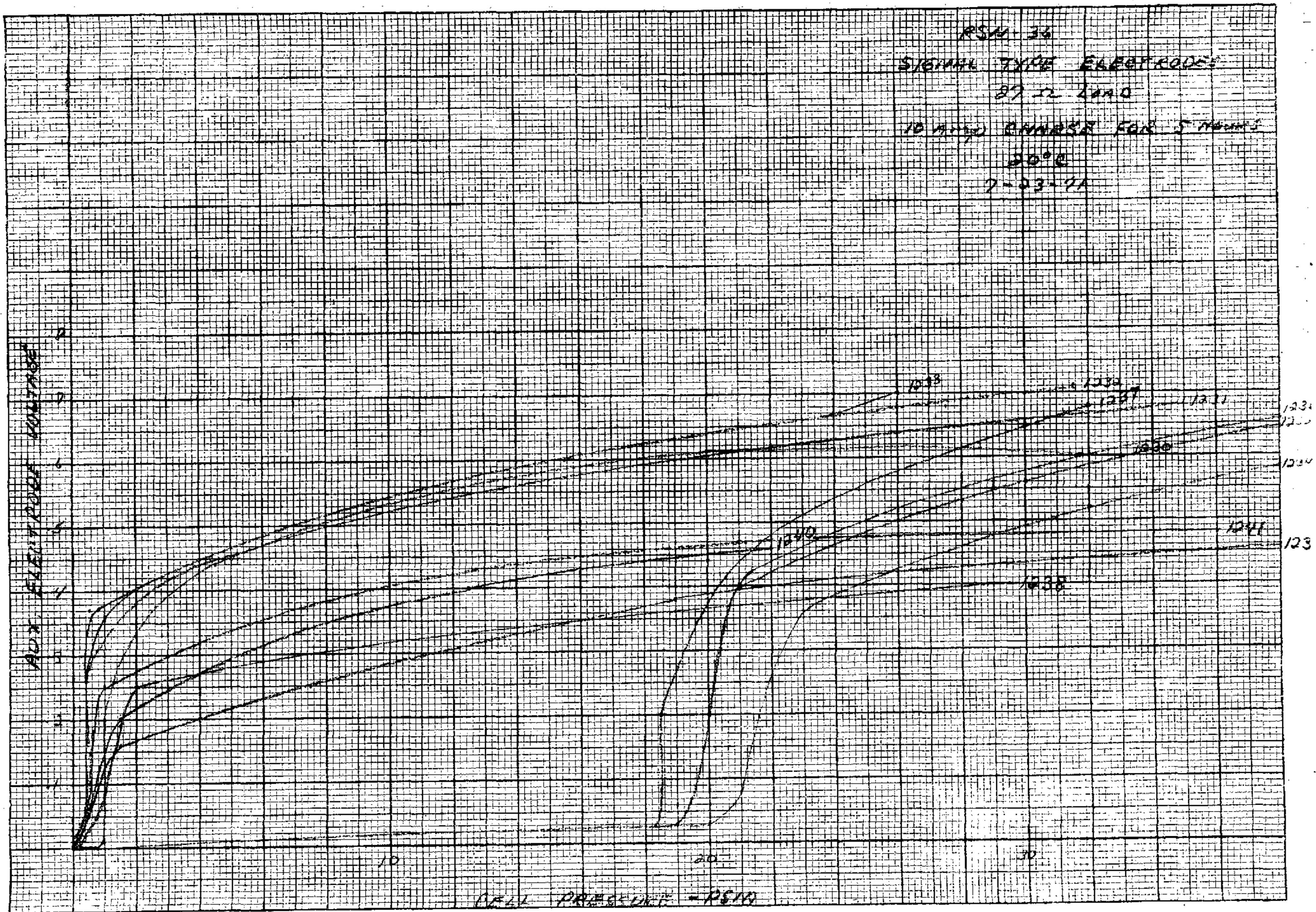


K&E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

FIGURE 37

AUXILIARY ELECTRODE




RSM-34
SIGNAL TYPE ELECTRODE
87 Ω Load
10 Amp CHARGE FOR 5 HOURS
20°C
7-23-71
AUX. ELECTRODE VOLTAGE
CELL PRESSURE - PSIA
10
20
30
1238
1234
1237
1231
1230
1240
1241
123
1238

GRUMMAN AEROSPACE CORPORATION

[redacted]

AVOID VERBAL ORDERS

APPENDIX L-4

FROM	M. Wertheim	553/POD	35	9142	DATE 2/7/72
	NAME	GROUP NO. & NAME	PLANT NO.	EXT.	
TO:	S. Gaston				NO. D559-2-3

SUBJECT: AUXILIARY ELECTRODE EVALUATION TESTS

Reference:
a) NAS 9-11074
b) Project Memorandum D559-2-1, 20 January 1972, "Minutes of Design Review Meetings at Eagle-Picher, January 17-19, 1972"
c) AVO D559-2-1, 19 January 1972

As indicated in the reference b) project memorandum, insufficient data to permit design of an auxiliary electrode control scheme has been developed to date. Accordingly, reference c) AVO requested (with concurrence from Eagle-Picher) shipment of cells to Grumman for further testing. These cells, S/N 24, 32, 36, 37 and 42, are now being shipped. Furthermore, an effort is underway in the laboratory to prepare for special testing.

Attached, please find a document entitled "Auxiliary Electrode Tests -- Outline of Tasks". This will be used for the planned tests. Since a schedule is in preparation, the personnel listed below are requested to prepare all schedule comments, and submit them to the writer by 11 February 1972, 12:00 noon:

S. Gaston
A. Winegard
D. Bickor
V. Falcone
J. Gambale

These comments may be informal, but should be in a form such that the writer can easily construct a complete schedule for this effort. Thank you for your cooperation.

INFO cc:

D. Bickor
J. Cioni (NASA/MSC)
V. Falcone
F. Ford (NASA/GSFC)
J. Gambale
W. Harsch (EP)
T. Hine
E. Miller
A. Winegard

AC 377 REV. 4

AUXILIARY ELECTRODE TESTS - OUTLINE OF TASKS

I. VISUAL INSPECTION

A. Assure the following:

1. Terminals straight, clean, free of visible damage around seals or ceramic.
2. Cover weld clean and without visible flaw.
3. No excess bulging of cell sides, faces, cover or bottom.
4. Serial number clearly visible on cell. Verify that cells are S/N 24, 32, 36, 37 and 42.
5. Shorting wire in place and tight.
6. Pressure gauge reads vacuum (-30 inches).
7. Stem between pressure gauge and fill tube is straight and undamaged
8. Valve on gauge "Tee" tightly closed (Remove valve knob to avoid unwanted opening.)
9. Verify presence of 27 Ω, 2 watt composition resistor between aux. electrode and negative terminals. If not, mount and connect resistors.

B. Record all inspection items.

C. X-ray S/N 36.

II. ASSEMBLY

A. Assemble cells S/N 24 and 42 in accordance with dwg. 559-117AV, except as indicated below.

B. Assemble cells S/N 32, 36 and 37 in accordance with dwg. 559-112AV, except as indicated below.

C. Each cooling plate assembly (P/N 559-111AV) shall first be deburred using belt sander and/or buffer on all edges, faces and corners as required.

D. Each cooling plate assembly, P/N 559-111AV-1, shall be connected to ½" ID inlet or outlet tubing (A/R) using 3/8" ID tubing as a mating sleeve. (See G. Below) Each inlet tube shall contain a coolant thermocouple.

E. Each cell shall be wrapped on both broad and narrow (side) faces using 0.001" thick "kapton" tape before final assembly.

F. Each string assembly shall use only one (1) temperature sensor resistor (R&F No. BN-200). That resistor shall be mounted and potted on P/N 559-111AV-3 cooling plate only. A thermocouple (STD gauge copper-constantan shall be assembled with each sensor.

G. For the two-cell assembly (P/N 559-117AV), the cooling plate assembly, P/N 559-111AV-5, shall be replaced by P/N 559-111AV-1.

H. Intercell connectors, P/N 559-113AV-23, shall <u>not</u> be used. Instead connectors made per the attached sketch shall be fabricated and used.

J. Enclose each assembly in a plastic bag with dessicant material (supplied by shipping). Plastic bag shall be heat sealed and entire bag assembly shall be insulated with fiberglass or equivalent insulation.

III. CONDITIONING CHARGE

A. Each string shall be charged at 10 amp rate for 16 hours, or until the first cell of the string reaches 1.51 volts.

B. The following conditions shall be observed.

1. Coolant flow shall be "maximum pump" ($\geqslant$ 30 lb/hour)
2. Coolant temperature shall be 55°F (bath 1)

C. The following shall be recorded:

1. Each cell voltage
2. Each auxiliary voltage
3. Each string current
4. Each cell pressure, psig
5. Each cell pressure, volts (transducer)
6. Each string temperature (on sensor)
7. Each coolant temperature (at inlet)

D. Recording shall be done using the DDAS, chart recorders, and hand readings as follows:

1. DDAS - mag tape (grocery tape as required)

    a. Interval: not greater than 6 minutes, except at end of charge (See 3. below)
    b. Recorded items: III.C.1-3, 5-7, time

2. Chart recorders:

    a. Recorded items: III.C.1, 2, 5 (each cell)

3. Hand Readings:

    a. Interval: not greater than 30 minutes, except at end of charge. At end of charge, use DDAS grocery tape on cell voltages <u>only</u> at sufficiently high rep. rates to assure that high cells will <u>not</u> exceed 1.515V.
    b. Recorded items: III.C.1-7, time; except at end of charge. Record (after chg. termination if required) all grocery tape cell voltages and times. Record end of charge pressures (III.C.4, 5).

IV. PERFORM PHENOLPHTHALEIN LEAK TEST ON EACH CELL

V. ORBITAL CYCLING

A. The two (2)-cell string (S/N 24 and 42) shall hereafter be known as <u>string 1</u>. The three (3)-cell string (S/N 32, 36 and 37) shall hereafter be known as <u>string 2.</u>

B. <u>Bath 2</u>, to be operated at 0°C inlet (32°F), shall use coolant consisting of 17% by volume (8.5 gallons) ethylene glycol in water solution. (freezing point = -6.7°C, 20°F.) <u>Bath 1</u>, to be operated at 12.8°C (55°F) inlet, may use either pure water or the above solution.

C. The following shall be recorded:

1. III.C.1-7
2. Time
3. Julian date
4. Alarm condition
5. Cumulative amp-hours

D. Recording shall be done using the DDAS and chart recorders. Hand recording shall be done only at the start and end of each test run. Recording shall be done as follows:

1. DDAS-mag tape (grocery tape as required)

    a. Interval: 1 minute
    b. Recorded items: V.C.1 (except III.C.4), 2, 3, 4

2. Chart recorders

    a. Recorded items: same as III.D.2.a and cumulative amp-hours as shown below.

E. Test runs

1. Each string shall be connected to a test controller using 30% DOD calibration.
2. String 1 shall be connected to Bath 1.
3. String 2 shall be connected to Bath 2.
4. Each string shall be run for 18 orbits (36 min. discharge, 58 min. charge) on three (3) successive days, six (6) orbits per day. If, after these runs, the pressure regime has stabilized, go on to the next step. If not, additional orbits shall be run , at the direction of the project engineer or his delegate, until stable regimes occur.
5. String 1 test controller shall be shifted to 50% DOD calibration. String 2 test controller shall be shifted to 12% DOD calibration. A minimum of fifteen (15) orbits (24 hours) shall be run continuously, or until pressure regime, end-of-discharge voltage, and aux. voltage regime are satisfactorily stable to the project engineer or his delegate. Active monitoring of this test shall occur only during the normal work-day. If it is not feasible to run unattended, the test shall be conducted at the rate of six (6) orbits per day.
6. Repeat step 5 with the following DOD calibrations:

    String 1 -- 12% DOD
    String 2 -- 50% DOD

7. Connect string 1 to bath 2, and string 2 to bath 1.
8. Repeat step 5 with the following DOD calibrations:

    String 1 -- 12% DOD
    String 2 -- 50% DOD

9. Repeat step 5 with both strings at 30% DOD calibration.
10. Repeat step 5 with the following DOD calibrations:

    String 1 -- 50% DOD
    String 2 -- 12% DOD

VI. OPTIMUM RESISTOR SELECTION

A. From the data of V above, four pressures (P_1, P_2, P_3, P_4) shall be selected ($P_1 < P_2 < P_3 < P_4$).

B. For the ensuing tests, the strings may remain assembled, but each cell shall be operated separately.

C. Bring the first cell to be tested to $P_1 \pm 10\%$ by charging it. Maintain this pressure by controlling charge rate. This cell shall be operated with coolant inlet of 55°F (bath 1). While maintaining pressure, vary the auxiliary electrode resistor in the steps shown below. At each resistor value, measure V_{AUX}.

Resistor Steps

1.0 Ω to 10 Ω , 1 Ω steps
10 Ω to 100 Ω , 5 Ω steps
100 Ω to 200 Ω , 10 Ω steps

D. Repeat step C with coolant inlet of 32°F (bath 2)

E. Repeat steps C and D with each other cell in turn (at P_1).

F. Repeat steps C through E at P_2

G. Repeat steps C through E at P_3

H. Repeat steps C through E at P_4

VII. CAPACITY DISCHARGE

A. Discharge all cells as follows:

1. Coolant inlet temperature = 55°F (bath 1)
2. Discharge current = 50 amp

Discharge until first cell in each string drops to 0.900V; record data per III C and III D.

B. After discharge is complete, place 0.2 Ω resistors across each cell for 16 hours.

NOTE: Step A may be performed using test controllers, 30% DOD calibration, in "discharge" mode with timing disabled.

VIII. PRESSURE/AUX. ELECTRODE SIGNAL

A. Connect string 1 to bath 1, and string 2 to bath 2. Use aux. resistor value from VI above.

B. Charge each string at 83.3 amp rate until either voltage limit (string) or aux. signal limit (first cell of string) is reached. Record data per III C and III D.

C. Discharge and drain strings per VII above

D. Repeat step B. above at 50.0 amp rate.

E. Repeat step C. above.

F. Repeat step B. above at 20.0 amp rate

G. Repeat step C. above

H. Repeat step B. above at 10.0 amp rate.

J. Repeat step C. above

K. Connect string 1 to bath 2, and string 2 to bath 1. Then repeat steps B through J above.

NOTE: Steps B, D, F and H above may be performed using the test controllers in "charge" mode, boards 2 and timing disabled. Charge rates may be set for B, D and F by artificially programming in turn the bases of the charge side 2N930 "shorting" transistors. Rate for step H may be set by artificially programming all charge side 2N930's, placing a 5K, 1% fixed (film) in series with a 50K, multiturn pot across R15/R16, and adjusting the pot until current is 10 amp.

GRUMMAN AEROSPACE CORPORATION

[redacted]

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APPENDIX L-5

FROM	SGaston S. Gaston	553/POD	35	9142	DATE 1/26/72
	NAME	GROUP NO. & NAME	PLANT NO.	EXT.	NO. D559-2-2

TO:

E. Carr/W. Harsch
J. Rogers, LM Subcontracts

SUBJECT: 100 A.H. BATTERY DEVELOPMENT PROGRAM - RECOMMENDED SOLUTIONS TO THE AUXILIARY ELECTRODE TAB-TO-CAN WELD AND ELECTRODES TAB-TO-SADDLE WELD PROBLEMS.

Reference:
a) Contract NAS 9-11074
b) GAC PO NO. 015161
c) Grumman meeting on 1/20/72 among Messrs S. Gaston, M. Wertheim (POD); D. Drucker (Reliability); A. Winegard (EED); and J. Greenspan and P. Dent (Metallurgy and Welding Eng.)

Enclosure:
1. X-ray photograph of auxiliary electrode view of cell S/N 14
2. GAC sketch 559-119AV, entitled Signal Type Auxiliary Electrode

Background:

Cell S/N 14 (a group I development cell) was dissected recently at Grumman and a design weakness of the auxiliary electrode tab-to-can fastening method was found. Figure 1 is an x-ray (positive) photograph of this area. It clearly depicts that the auxiliary tab forms a bend touching several layers of separator in the plate stack. This is undesirable, since a short between the auxiliary and the storage electrodes could be induced. In addition, two (2) nicks across the tab's width in close proximity to the tab-to-can weld area were observed. Since, during the cell's assembly, the cover is forced onto the can while this tab is sandwiched inbetween, tab damage can occur (tab material is 0.005" soft nickel). This procedure is therefore not suitable for a high reliability component. It is felt by Grumman that some of the inconsistent auxiliary electrode signal results observed on the development cells could be due to this design technique, and the resulting contact uncertainty.

Recommendations:

The above problem was discussed at Grumman among personnel from the metallurgical group, mechanical design, and this project. The following two alternate auxiliary electrode tab weld constructions have been proposed as potential solutions:

1. Preferred design - Shown in attached sketch 559-119AV. The auxiliary nickel tab is shortened and spot welded to a stainless steel strip which is fed through a slot in the cover. A shoulder on the tab provides a stop when pulling the tab through the cover. This pull-up should eliminate the tab-to-separator loop which may cause a short. The strip is then welded to the cover, forming a stainless-to-stainless joint. The dimensions shown on this sketch are for reference only and can be modified, if required.

2. Alternate design - The existing tab design could be welded to the underside of the cover at a position close to that shown on 559-119AV. However, precautions must be taken to obtain a good spot weld due to dissimilar materials (nickel and stainless) and thickness differences (0.005" vs. 0.050"). This design will not require a slot

GAC 377 REV. 4

in the cover but requires very close spotweld control to prevent poor or burned ints.

Other Recommendations:

A review of the positive and negative electrodes tab-to-saddle joints shows that a combined compression and a welding operation is used. It is recommended that the compression step be separated from the welding step to assure a better joint. The pre-compression should be at a higher force level than that used during the welding.

In addition there are strong indications that a higher cleanliness level is required around the areas to be welded. All components should be thoroughly cleaned prior to welding and subsequently handled only with lint free gloves. Also, cutting tools be thoroughly cleaned and degreased, if they are used after the components are cleaned (e.g.: tab cutting tools). A tight welding schedule shall be established, and enforced by approved quality control techniques.

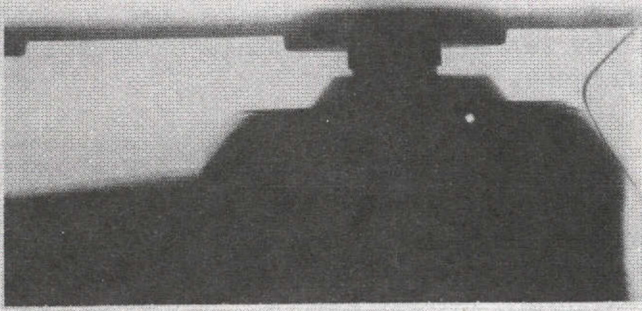
Requested Action:

Eagle Picher is hereby requested to review the above findings and recommendations and to submit their modifications to Grumman for review. In addition, sample weld joints shall be submitted to Grumman for conductivity and metallurgical analyses prior to incorporation in the design and production.

Eagle Picher action is urgently required since these modifications must be incorporated into the next group of 27 cells.

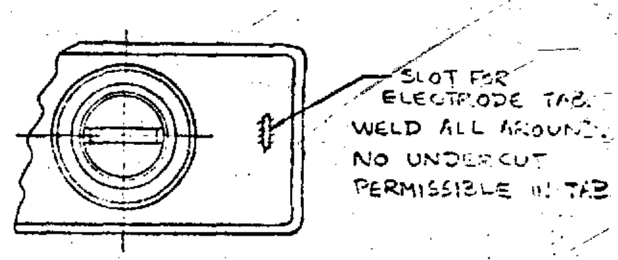
INFO cc:

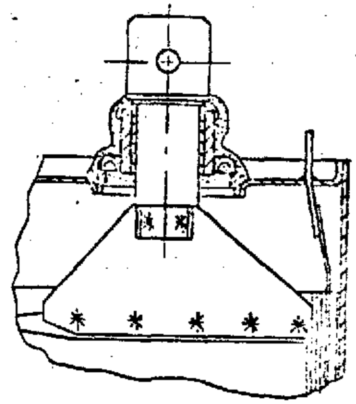
J. Cioni, NASA/MSC
P. Dent
D. Drucker, Rel. Plt. 14
F. Ford, NASA/GSFC
J. Greenspan, Chem. Lab. Plt. 12
R. Mallard, GAC at EP
S. Orehosky, OAO, QC
R. Wannamaker, NAVPRO
M. Wertheim
A. Winegard

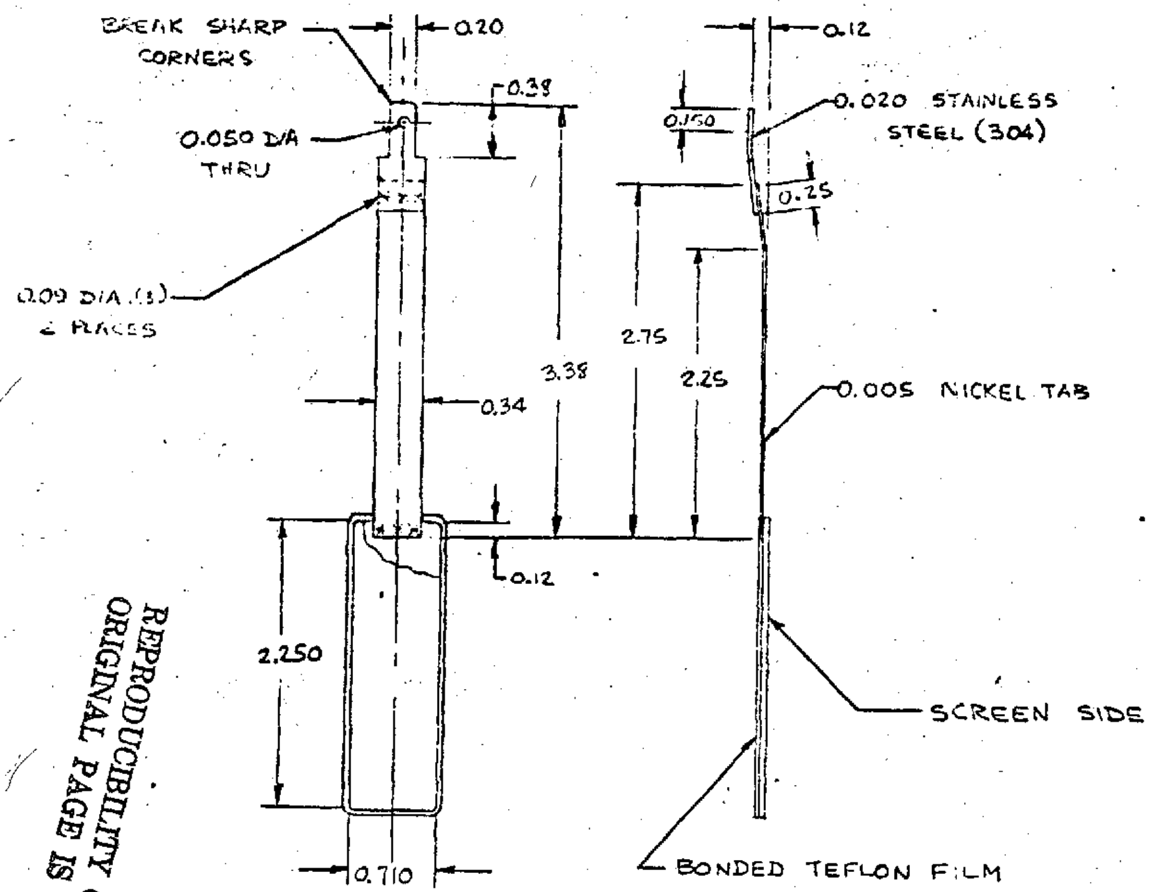


X RAY PHOTOGRAPH OF CELL S/N 14

FIGURE 1







SIGNAL TYPE AUXILIARY ELECTRODE

SCALE - FULL 1-21-72 AW

559-119AV

PRELIMINARY

GRUMMAN AEROSPACE CORPORATION

APPENDIX M

Mechanical Test Procedure,

Comments & Test Data

APPENDIX M-1

FEB 2 2 1972

QTP-169

QUALIFICATION TEST PROCEDURE
FOR
EAGLE-PICHER CELL RSN-110

25 JANUARY 1972

PREPARED FOR
GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK 11714

GRUMMAN P.O. NO. 015161

EAGLE-PICHER INDUSTRIES, INC.
ELECTRONICS DIVISION
COUPLES DEPARTMENT
JOPLIN, MISSOURI
64801

APPROVAL PAGE

QUALIFICATION TEST PROCEDURES
FOR
EAGLE-PICHER CELL RSN-110

PREPARED BY: William C Harsch
William C. Harsch
Project Engineer

REVIEWED BY: Paul Cantrell
Paul Cantrell
Environmental Engineering Supervisor

APPROVED BY: ______________________
Earl S. Carr
Engineering Manager, Ni-Cd

APPROVED BY: Stephen J. Gaston
Steve J. Gaston
GAC Project Engineer

APPROVED BY: ______________________
E. E. Miller
GAC Project Manager

1.0 SCOPE

1.1 Purpose

This document outlines the procedure for the qualification testing of a sealed, activated, nickel-cadmium rechargeable cell. The cell referred to herein is the Eagle-Picher RSN-110 cell for Grumman Aerospace Corporation.

1.2 Test Plan

The objective of the tests defined in Paragraph 4.0 herein are to verify that the RSN-110 cell is capable of satisfying the requirements of Grumman Specification AV-D559CS-1.

The tests to be conducted are as defined in Paragraph 4.0 and shall be to the levels and durations specified.

Two (2) RSN-110 cells shall be tested. The quantity of cells to be tested and the tests to which they will be subjected were chosen by GAC and Eagle-Picher Engineering, and are believed to be representative of the extreme requirements to be imposed upon the unit.

Upon completion of the tests, all data shall be evaluated by Eagle-Picher Engineering. In the event of a test failure, an Engineering Failure Analysis will be performed and a report submitted to GAC. A final test report presenting the actual results of the tests will be prepared upon completion of the tests and will be submitted to GAC within 30 days after completion of the tests.

2.0 APPLICABLE DOCUMENTS

GAC Specification AV-D559CS-1

Eagle-Picher Drawing 005328 Cell Outline

Cell Development Test Plan, DVTP-153-1

3.0 TEST CONDITIONS

3.1 Unless otherwise specified, the qualification testing shall be performed at an atmospheric pressure of 28.0 to 32.0" mercury of a temperature from 60° to 90°F and a relative humidity of 90% or less. A record of time versus voltage, current and temperatures shall be recorded during each test when applicable.

3.2 Test Tolerances

Unless otherwise specified, the maximum allowable tolerance on test conditions are as follows:

a. Sinusoidal Vibration Amplitude (g or in.)	±10% of peak level measured at input frequency
b. Sinusoidal Vibration Frequency	±2%
c. Random Vibration	±3 db (the overall rms-g applied shall be maintained within a tolerance of $^{+15\%}_{-5\%}$)
d. Shock (g & sec.)	±10% (peak g level)
e. Acceleration (g)	±5%
f. Voltage	±0.5%
g. Current	±0.5%
h. Time	±2%

4.0 ENVIRONMENTAL TESTING

Prior to any environmental testing, the cell shall be tested per Paragraph 4.6 of this procedure. The qualification tests shall consist of the following tests in the sequence shown.

4.1 Vibration Fixture Test

4.1.1 Equipment Required

Vibration System (Sine)

4.1.2 Fixture Test Procedure

1) Mount fixture with dummy test cell on vibrator.
2) Subject fixture and dummy cell to the test conditions listed below for the cell test.
3) Monitor the vibration input with tri-axial accelerometers.

4.1.3 Fixture Test Requirements

The fixture and its connection to the shaker head, shall be capable of transmitting the vibrations specified. It shall be a design objective that the fixtures be free of resonances within the test frequencies. In any event, the fundamental resonance of the fixture compensated for test unit mass shall be above 750 Hz. The transverse motion (crosstalk) in any direction produced by this fixture shall not exceed the vibration levels in the transverse direction specified.

4.2 Sinusoidal Vibration

4.2.1 Equipment Required

Vibration System (Sine)
Recording Oscillograph
Charge Panel, E-P Test Aid #1
Discharge Panel, E-P Test Aid #2

4.2.2 Test Procedure

1) Connect cell to charge panel, E-P Test Aid #1, Figure 1, and charge at 30 amps for 5 hours or to a cell voltage of 1.50 volts, whichever comes first.

2) Mount the cell to the vibration test machine by means of a fixture as shown in Figure 3.

3) Subject the cell to the following sinusoidal vibration conditions in each of the three (3) mutually perpendicular axes. The cell shall be vibrated in the X-X', Y-Y' and Z-Z' axes as shown on the positional sketch, Figure 4.

Frequency Range (Hz)	Acceleration (0 to Peak)
5 - 35	0.5 in. D.A.
35 - 2000	30 g

Sweeping frequency at a rate of two (2) octaves per minute.

4) Discharge the cell at a 50 ampere rate during the vibration using Test Aid #2, Figure 2.

5) Monitor terminal voltage and current continuously during vibration test by means of a recording oscillograph.

6) X-Y plots of the vibration test accelerometer shall be made.

4.2.3 Test Requirements

The current and voltage values observed during discharge shall show no fluctuations. Visual inspection of the cell, upon completion of the test, shall show no mechanical failure.

4.3 Random Vibration

4.3.1 Equipment Required

Vibration System (Random)

Recording Oscillograph

Discharge Panel, E-P Test Aid #2

4.3.2 Test Procedure

1) With the cell still mounted to the vibration machine from the previous test, subject the cell to the following random vibration conditions in each of the three (3) mutually perpendicular axes.

Frequency Hz	Level
20 - 200	9 db/octave increase
200 - 500	0.13 g^2/Hz
500 - 2000	3 db/octave decrease

Sweep frequencies for four (4) minutes per axis.

2) The cell shall be vibrated in the X-X', Y-Y' and Z-Z' axes as shown on the positional sketch, Figure 4.

3) Discharge the cell at a 50 ampere rate during vibration.

4) Monitor terminal voltage and current continuously during vibration test by means of a recording

oscillograph.

5) X-Y plots of the vibration test accelerometer shall be made.

6) After vibration test has been completed, discharge the cell at 50 amperes to 0.9 volts. Record time to 1.00 volt and 0.9 volts.

4.3.3 Test Requirements

The current and voltage values observed during discharge shall show no fluctuations. Visual inspection of the cell, upon completion of the test, shall show no mechanical failure.

4.4 Shock Test

4.4.1 Equipment Required

Shock Machine

Recording Oscillograph

Charge Panel, E-P Test Aid #1

Discharge Panel, E-P Test Aid #2

4.4.2 Test Procedure

1) Connect the cell to E-P Test Aid #1 and charge at 30 amps for 5 hours or to a terminal voltage of 1.50 volts, whichever comes first.

2) Mount the cell to the shock machine by means of a fixture as shown in Figure 3.

3) Subject the cell to a shock of 30 g's in each direction along each of the three (3) mutually perpendicular axes. Each shock shall be of 10 to 15 milliseconds duration with 1/2 sine pulse shape. The cell shall be shocked in the X-X', Y-Y' and Z-Z' axes as shown on positional sketch, Fig. 4.

4) Discharge the cell at the 50 ampere rate during each shock pulse.

5) Monitor the terminal voltage and current continuously during each shock drop. Monitoring device shall be a recording oscillograph.

4.4.3 Test Requirements

The current and voltage values observed during discharge shall show no fluctuations. Visual inspection of the cell, upon completion of the test, shall show no mechanical failure.

4.5 Acceleration Test

4.5.1 Equipment Required

Centrifuge

Recording Oscillograph

Discharge Panel, E-P Test Aid #2

4.5.2 Test Procedure

1) The cell is received from shock test in a charged state.

2) Mount the cell to the centrifuge by means of a fixture as shown in Figure 3.

3) Subject the cell to acceleration of 11.3 g's for a period of five (5) minutes, applied in both directions along each of the three (3) mutually perpendicular axes. The cell shall be accelerated in the same sequence of positions shown in Paragraph 4.4.2, Step 3.

4) Monitor the terminal voltage and current continuously during the acceleration test by means of a recording oscillograph.

5) Discharge the cell at the 50 ampere rate during acceleration.

6) After the acceleration test is complete, discharge the cell at 50 amperes to 0.9 volts. Record time to 1.00 volt and 0.9 volts.

4.5.3 Test Requirements

The current and voltage values observed during discharge shall show no fluctuations. Visual inspection of the cell, upon completion of the test, shall show no mechanical failure.

4.6 Functional Testing

The cell shall be subjected to the following tests from the Cell Development Test Plan (DVTP-153-1).

1) Paragraph 3.6.8 Overcharge (Test 6)

2) Paragraph 3.6.9 Phenolphthalein Leak Check (Test 7)

In addition, the cell shall be X-rayed through the X-X' and the Y-Y' axes.

5.0 DATA CONFIRMATION

All data generated during the various phases of this qualification test shall be recorded on the Qualification Test Data Sheets for RSN-110. The forms shall be checked for exactness, completeness, signatures and proper initialling. A copy of the completed test forms shall be included in an Appendix to the Qualification Test Report.

6.0 EQUIPMENT AND INSTRUMENTATION LIST

TYPE	MFG. NAME*	MODEL
Acceleration Machine	Raymond	15000
Vibration System (Sine)	Ling	R-1001
Vibration Power Supply	Ling	PP-60/80A
Vibration Exciter	Ling	275A
Vibration System (Random)	Ling	ESD/ASD-40
Accelerometer	Endevco	2228B
Shock Machine	Barry	20V-1
Charge Panel	Eagle-Picher	E-P Test Aid #1
Discharge Panel	Eagle-Picher	E-P Test Aid #2
Voltmeter (Digital)	Fairchild	7100
Ammeter	Weston	931
Power Source	Sorenson	
Recording Oscillograph	CEC	5-124
Shunt	Weston	

*Equivalent Equipment may be used.

APPENDIX

(DATA SHEETS)

E-P TEST AID # 1

CHARGE PANEL

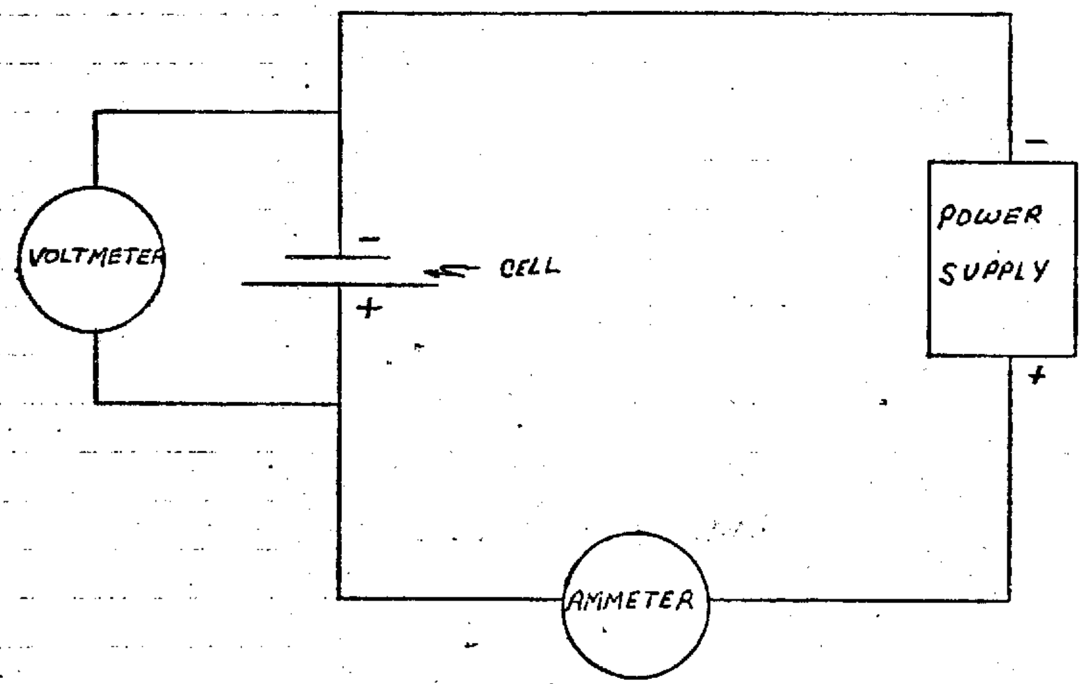


FIGURE NO. 1

E-P TEST AID # 2

DISCHARGE PANEL

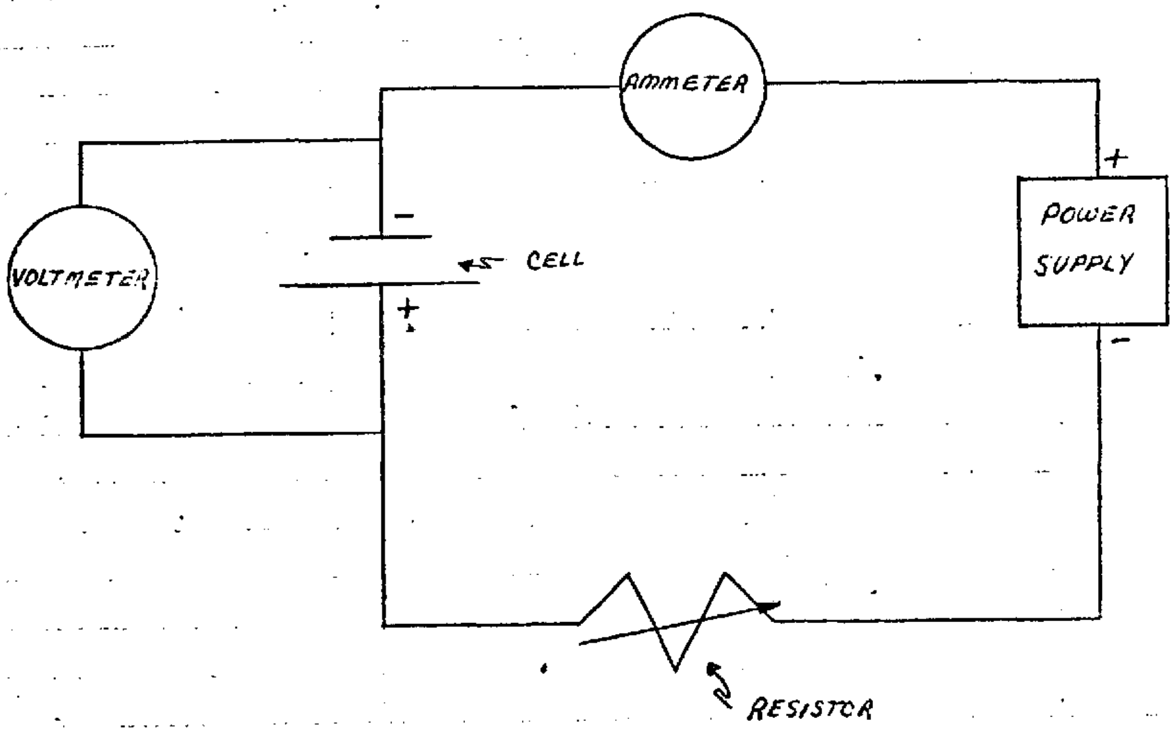


FIGURE NO. 2

MOUNTING FIXTURE

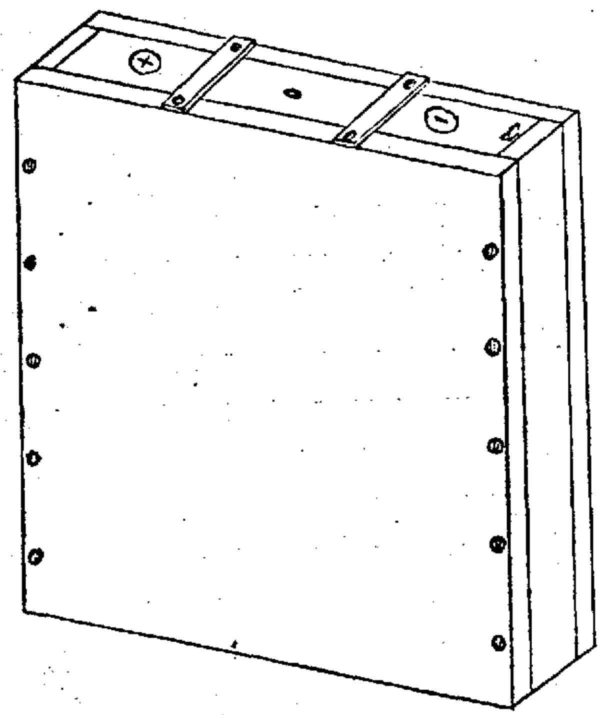


FIGURE NO. 3

POSITIONAL SKETCH

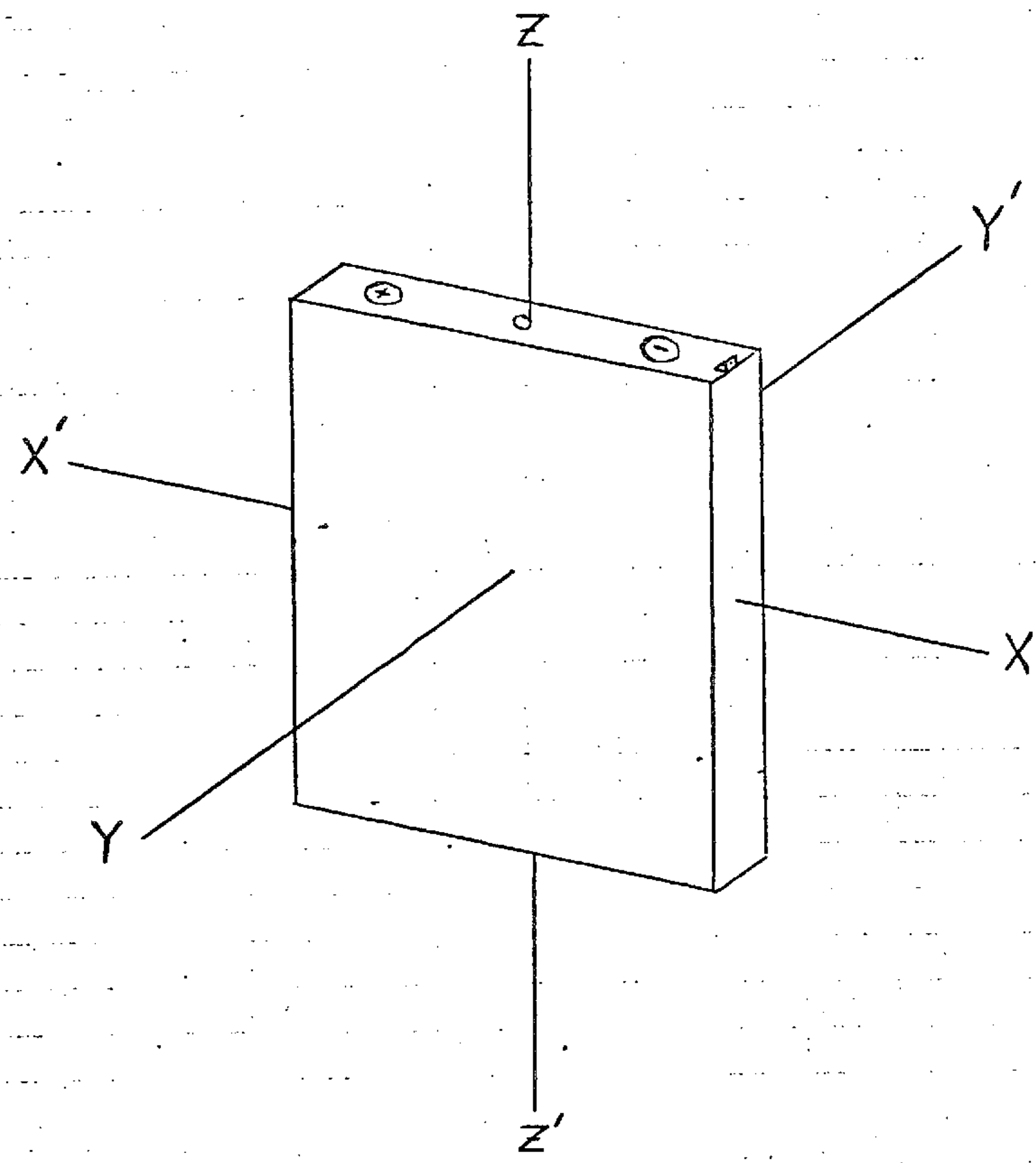


FIGURE NO. 4

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant - Joplin, Missouri

TYPE TEST: OVERCHARGE (Pre-Test)

TEST SPECIMEN NO. ______

TEST PROCEDURE NO. EVTP-153-1

TEST PARA. REF. NO. 3.6.8 TEST 6

AMBIENT TEMP. 72 °F

BATT. TEMP. Recorded °F

DATE ______ TIME ______

E. P. BAT. TYPE RSN-110 S. N. ______

6AC BAT. NO. RSN-110

TYPE PROGRAM: PROD. ☐ QUAL. ☒ R & D ☐

PREVIOUS TEST: GROUP III TESTING

CHARGE AT 30 AMPS TO 1.51 VOLTS

TIME	VOLTS	AMPS	AUX. VOLTS	TEMP.	
OCV					
T=0					
T=1					
30 MIN.					
1 HOUR					
30 MIN.					
2 HOURS					
30 MIN.					
3 HOURS					
15 MIN.					
30 "					
45 "					
4 HOURS					

TIME TO 1.51 VOLTS =

CHARGE RATE TO 10 AMPS

TIME	VOLTS	AMPS	AUX. VOLTS	TEMP.	
T=0					
T=1					
30 MIN					
1 HOUR					
2 "					
3 "					
4 "					
5 "					
6 "					
7 "					
8 "					

RECORD RESULTS OF PHENOLPHTHALEIN TEST PER EVTP-153-1 PARA 3.6.9

COLORATION =

DISCHARGE AT 50 AMPS TO 0.9 VOLTS

TIME	VOLTS	AMPS	AUX VOLTS	TEMP.	
OCV					
T=0					
T=1					
15 MIN.					
30 "					
45 "					
1 HOUR					
15 MIN					
30 "					
45 "					
2 HOUR					
15 MIN					
30 "					

TIME TO 1.00 VOLTS =

TIME TO 0.9 VOLTS =

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

TF-41 WHITAKER PTG 5787

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant · Joplin, Missouri

TYPE TEST: CHARGE BEFORE VIBRATION — TEST SPECIMEN NO. ______

TEST PROCEDURE NO. QTP-169 — DATE ______ TIME ______
TEST PARA. REF. NO. 4.3 — E. P. BAT. TYPE RSN-110 S. N. ______
AMBIENT TEMP. NA °F — GAC BAT. NO. RSN-110
BATT. TEMP. NA °F — TYPE PROGRAM: PROD. ☐ QUAL. ☒ R & D ☐
PREVIOUS TEST: OVERCHARGE

CHARGE AT 30 Amps TO 1.50 VOLTS

TIME	VOLTS	AMPS	AUX VOLTS			TIME	VOLTS	AMPS			
OCV											
T=0											
T=1											
30 MIN											
1 HOUR											
30 MIN.											
2 HOURS											
30 MIN.											
3 HOURS											
15 MIN.											
30 "											
45 "											
4 HOURS											

TIME TO 1.50 VOLTS =

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

TF-41 WHITAKER PTG 0327

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant - Joplin, Missouri

TYPE TEST: Sinusoidal Vibration

TEST SPECIMEN NO. ______

TEST PROCEDURE NO. QTP-117
TEST PARA. REF. NO. 4.2
AMBIENT TEMP. NA °F
BATT. TEMP. NA °F

DATE ______ TIME ______
E. P. BAT. TYPE RSN-110 S. N. ______
GAC BAT. NO. RSN-110
TYPE PROGRAM: PROD. ☐ QUAL. ☒ R & D ☐
PREVIOUS TEST: OVERCHARGE

DISCHARGE AT 50 AMPS DURING VIBRATION

X - X' AXIS

TIME	VOLTS	AMPS	AUX. VOLTS			TIME	VOLTS	AMPS			
OCV											
1 min.											
2 "											
3 "											
4 "											
5 "											
Y - Y' AXIS											
OCV											
1 min											
2 "											
3 "											
4 "											
5 "											
Z - Z' AXIS											
OCV											
1 min.											
2 "											
3 "											
4 "											
5 "											

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant - Joplin, Missouri

TYPE TEST: Random Vibration
TEST PROCEDURE NO. QTP-169
TEST PARA. REF. NO. 4.3
AMBIENT TEMP. NA °F
BATT. TEMP. NA °F

TEST SPECIMEN NO.
DATE TIME
E. P. BAT. TYPE RSN-110 S. N.
GAC BAT. NO. RSN-110
TYPE PROGRAM: PROD. ☐ QUAL. ☒ R & D ☐
PREVIOUS TEST: Sinusoidal Vibration

DISCHARGE AT 50 AMPS DURING VIBRATION

X - X' AXIS

TIME	VOLTS	AMPS	AUX VOLTS.		
OCV					
1 min					
2 "					
3 "					
4 "					
5 "					

Y - Y' AXIS

TIME	VOLTS	AMPS	AUX VOLTS.		
OCV					
1 min					
2 "					
3 "					
4 "					
5 "					

Z - Z' AXIS

TIME	VOLTS	AMPS	AUX VOLTS.		
OCV					
1 min					
2 "					
3 "					
4 "					
5 "					

COMPLETE DISCHARGE AFTER VIBRATION

TIME	VOLTS	AMPS	AUX VOLTS		
OCV					
T = 0					
T = 1					
15 min.					
30 "					
45 "					
1 Hour					
15 min					
30 "					
45 "					
2 Hours					

TIME TO 1.00 VOLTS =
TIME TO 0.9 VOLTS =

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

EAGLE-PICHER INDUSTRIES, INC.

Couples Plant · Joplin, Missouri

TYPE TEST: CHARGE BEFORE SHOCK

TEST SPECIMEN NO. ______

TEST PROCEDURE NO. QTP-169

TEST PARA. REF. NO. 4.4

AMBIENT TEMP. NA °F

BATT. TEMP. NA °F

DATE ______ TIME ______

E. P. BAT. TYPE [illegible]-110 S. N. ______

SAC BAT. NO. [illegible]-110

TYPE PROGRAM: PROD. ☐ QUAL. ☒ R & D ☐

PREVIOUS TEST: RANDOM VIBRATION

CHARGE AT 30 AMPS TO 1.50 VOLTS

TIME	VOLTS	AMPS	AUX VOLTS			TIME	VOLTS	AMPS			
OCV											
T=0											
T=1											
30 MIN.											
1 HOUR											
30 MIN.											
2 HOURS											
30 MIN											
3 HOURS											
15 MIN											
30 "											
45 "											
4 HOUR											
	TIME TO 1.50 VOLTS =										

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

TF-41 WHITAKER PTG 6387

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant - Joplin, Missouri

TYPE TEST: SHOCK

TEST PROCEDURE NO. QTP-189
TEST PARA. REF. NO. 4.4
AMBIENT TEMP. NA °F
BATT. TEMP. NA °F

TEST SPECIMEN NO. ______
DATE ______ TIME ______
E. P. BAT. TYPE RSN-110 S. N. ______
GAC BAT. NO. RSN-110
TYPE PROGRAM: PROD. ☐ QUAL. ☒ R & D ☐
PREVIOUS TEST: Random Vibration

DISCHARGE AT 50 AMPS DURING SHOCK

TIME	VOLTS	AMPS	AUX. VOLTS		
	X - X' AXIS				
OCV					
1 MIN.					
2 MIN					
	X' - X AXIS				
OCV					
1 MIN.					
2 MIN.					
	Y - Y' AXIS				
OCV					
1 MIN.					
2 MIN.					
	Y' - Y AXIS				
OCV					
1 MIN.					
2 MIN.					
	Z - Z' AXIS				
OCV					
1 MIN.					
2 MIN.					
	Z' - Z AXIS				
OCV					
1 MIN.					
2 MIN.					

TIME	VOLTS	AMPS			

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant - Joplin, Missouri

TYPE TEST: Acceleration TEST SPECIMEN NO. ______

TEST PROCEDURE NO. QTP-169 DATE ______ TIME ______
TEST PARA. REF. NO. 4.5 E. P. BAT. TYPE RSN-110 S. N. ______
AMBIENT TEMP. NA °F GAC BAT. NO. RSN-110
BATT. TEMP. NA °F TYPE PROGRAM: PROD. ☐ QUAL. ☒ R & D ☐
PREVIOUS TEST: SHOCK

DISCHARGE AT 50 AMPS DURING ACCELERATION

X - X' AXIS

TIME	VOLTS	AMPS	AUX VOLTS		
OCV					
1 min.					
2 "					
3 "					
4 "					
5 "					

X' - X AXIS

TIME	VOLTS	AMPS	AUX VOLTS		
OCV					
1 min.					
2 "					
3 "					
4 "					
5 "					

Y - Y' AXIS

TIME	VOLTS	AMPS	AUX VOLTS		
OCV					
1 MIN					
2 "					
3 "					
4 "					
5 "					

Y' - Y AXIS

TIME	VOLTS	AMPS	AUX VOLTS		
OCV					
1 MIN.					
2 "					
3 "					
4 "					
5 "					

Z - Z' AXIS

TIME	VOLTS	AMPS	AUX VOLTS		
OCV					
1 MIN					
2 "					
3 "					
4 "					
5 "					

Z' - Z AXIS

TIME	VOLTS	AMPS	AUX VOLTS		
OCV					
1 MIN.					
2 "					
3 "					
4 "					
5 "					

COMPLETE DISCHARGE AFTER ACCELERATION

TIME					
OCV					
T = 0					
T = 1					
15 MIN.					
30 "					
45 "					
1 HOUR					
15 MIN.					
30 "					
45 "					
2 HOURS					

TIME TO 1.00 VOLT =
TIME TO 0.9 VOLTS =

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

TF-41 WHITAKER PTG 6187

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant · Joplin, Missouri

TYPE TEST: OVERCHARGE (Post-Test)

TEST SPECIMEN NO. ______

TEST PROCEDURE NO. DVTP-153-1
TEST PARA. REF. NO. 3.6.8 TEST 6
AMBIENT TEMP. 68 °F
BATT. TEMP. Recorded °F

DATE ______ TIME ______
E. P. BAT. TYPE RSN-110 S. N. ______
GAC BAT. NO. RSN-110
TYPE PROGRAM: PROD. ☐ QUAL. ☒ R & D ☐
PREVIOUS TEST: Acceleration

CHARGE AT 30 AMPS TO 1.51 VOLTS

TIME	VOLTS	AMPS	AUX VOLTS	TEMP.	
OCV					
T=0					
T=1					
30 min					
1 Hour					
30 min.					
2 Hours					
30 min.					
3 Hours					
15 min.					
30 min					
45 "					
4 Hours					

TIME TO 1.51 VOLTS =

CHANG RATE TO 10 AMPS

TIME	VOLTS	AMPS	AUX VOLTS	TEMP.	
T=0					
T=1					
30 min					
1 Hour					
2 "					
3 "					
4 "					
5 "					
6 "					
7 "					
8 "					

RECORD RESULTS OF PHENOLPHTHALEIN TEST
PER DVTP-153-1 PARA. 3.6.9
COLORATION =

DISCHARGE AT 50 AMPS TO 0.9 VOLTS

TIME	VOLTS	AMPS	AUX VOLTS	TEMP.	
OCV					
T=0					
T=1					
15 min.					
30 "					
45 "					
1 Hour					
15 min.					
30 "					
45 "					
2 Hour					
15 min.					
30 "					

TIME TO 1.00 VOLT =
TIME TO 0.9 VOLTS =

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

TP-41 WHIT-KER [illegible]

GRUMMAN AEROSPACE CORPORATION

AVOID VERBAL ORDERS

APPENDIX M-1

FROM	S. Gaston	553/POD	35	9142	DATE 3/22/72
	NAME	GROUP NO. & NAME	PLANT NO.	EXT.	NO. D559-2-8

TO:

J. Rogers
E. Carr/W. Harsch

SUBJECT: APPROVAL AND COMMENTS ON THE EAGLE PICHER SUPPLIED QUALIFICATION TEST PROCEDURE, QTP-169, DATED JANUARY 25, 1972.

Reference: a) Contract NAS 9-11074
b) Grumman PO No. 015161
c) Grumman cell specification AV-D559-CS-1
d) Eagle Picher Qualification Test Procedure for RSN-110 cell, dated January 25, 1972, received at Grumman on February 22, 1972.

Grumman hereby approves the above referenced d) plan, provided that all of the below listed comments are included:

1. On title page - change "Qualification" to "Environmental". (Qualification tests include performance and environmental tests, as defined in Paragraph 4.3 of the above reference c) cell specification).
2. On approval page - same as above comment 1.
3. On paragraph 1.1 - ditto.
4. On paragraph 1.2, first paragraph - After "AV-D559CS-1" - add "paragraph 4.3.2".
5. On paragraph 1.2, second paragraph - remove "4.0" and replace by "4.3.2".
6. On paragraph 1.2, third paragraph - delete and replace by:
"A minimum of two (2) RSN-110 cells shall be tested. Development cell S/N 33 (thin plate) and development cell S/N 44 (baseline plate) and alternate cells S/N 35 (thin plate) and S/N 44 (baseline plate) were chosen by Grumman and Eagle Picher Engineering for these mechanical tests. Grumman QC at Eagle Picher will be notified a minimum of 48 hours prior to start of these tests".
7. On paragraph 1.2, fourth paragraph, first sentence, after "Eagle Picher" add "Grumman".
8. On paragraph 1.2, fourth paragraph, second sentence after "test failure" - add "Grumman Engineering and QC will be notified immediately and".
9. On paragraph 3.1 - change "qualification" to "environmental". After "32.0" add "of". After "mercury" replace "of a" by "and an ambient". Replace "90%" by "85%". After "voltage" add "(cell and auxiliary signal)".
10. On paragraph 3.2 f, g, h - add "Data Acquisition System shall be used".
11. On paragraph 4.0 - replace "qualification" by "environmental".
12. On paragraph 4.1.2, 1) after "fixture" add "as shown in Figure 3".
13. On paragraph 4.1.2, 3) delete in its entirety and replace by:
"3) Monitor the virbration input and response (output) to the four (4) corner locations in axis with tri-axial accelerometers to determine its resonant frequency."

14. On paragraph 4.1.3 add to end of paragraph "The data shall be reviewed on location for optimum control points to be selected."

15. On paragraph 4.2.2. 1) delete "for 5 hours or" replace "whichever comes first" by "or to a maximum cell pressure of +10 psig."; - since cell was fully charged prior to this charge as shown in paragraph 4.6. The data acquisition system shall be used for current, auxiliary and cell voltage readings at three (3) minute minimum intervals.
Add to end of this paragraph "The cells pressure gage must be removed and replaced by a plug after completion of this charge. In addition the cell's auxiliary electrode signal resistor shall be removed. The cell shall subsequently be electrically insulated from the fixture. This can be achieved by first removing any protruding metal particles on the cell-to-fixture mating surfaces by means of a metal file. The cell shall subsequently be wrapped in a number of layers of Kapton. A thermocouple shall be securely mounted on an exposed cell metal surface and insulated from the ambient.) The cell shall then be placed in the fixture as shown on Figure 3 under a "clamp up" load of 6000 pounds, as specified in paragraph 4.5.8 of Grumman specification AV-D559CS-1. An electrical insulation resistance check between cell and fixture shall then be conducted. The minimum acceptable resistance using a 50 VDC source shall be 50 mega-ohms. The exact technique used shall subsequently be described in the test report."

16. On paragraph 4.2.2, 2) add to end of this paragraph "The exact mounting technique shall be described in the test report. Pictures showing details shall also be included."

17. On paragraph 4.2.2, 3) second sentence after "vibrated in the" add "following sequence".

18. On paragraph 4.2.2, 4) replace "during" by"for 2 minutes prior, during and for 2 minutes after".
Delete "Test Aid #2 and replace by "Standard test set-up as used for the cell development tests".

19. On paragraph 4.2.2, 5) after "voltage" add ", auxiliary electrode voltage and insulation resistance between cell case and fixture".
Add to end of paragraph "The same parameters shall be recorded on the data acquisition system at 15 second intervals for the entire discharge duration as specified above."

20. On paragraph 4.2.2, 6) after accelerometer add "input and response".

21. On paragraph 4.2.3, 1) replace "sweep frequencies for" by "Duration".
Add to end of paragraph - "Ten (10 second random burst shall be performed and analyzed prior to the random run to verify if the spectrum is within the required tolerance. The 10 second burst(s),if within specification, can be considered as part of the random test time requirement".

22. On paragraph 4.3.2, 3) add after rate "for two (2) minutes prior.". After "during" add "and for two (2) minutes after completion of".

23. On paragraph 4.3.2, 4) - See above comment No. 19.

24. On paragraph 4.3.2, 5) delete and replace by "compliance with the test tolerances shall be verified by analysis of the input control accelerometer. The analysis parameters shall be selected to yield a minimum statistical accuracy of 120 degrees of freedom. The resulting analysis shall be presented on log-log x-y plots of power spectral density (g^2/Hz) versus frequency (Hz)."

25. On paragraph 4.3.2, 6) add to end of paragraph - "In addition to the cell voltages, the auxiliary electrode voltage, current and cell temperature shall be recorded at three (3) minute minimum intervals using the data acquisition system."

26. On paragraph 4.3.3 - after voltage add "auxiliary signal and insulation resistance". To end of paragraph add "A phenolpthalein leak test shall be conducted on all weld seams and terminal areas. Any positive indication shall be subject to further leak verification."

27. On paragraph 4.4.2, 1) replace "E-P Test Aid #1" by "normally used equipment for the development cell tests including data acquisition system, scanning frequency not to exceed fifteen (15) minute intervals."

28. On paragraph 4.4.2, 2) - same insulation requirements are applicable as listed in above comments no. 15. 15

29. On paragraph 4.4.2, 4) - see above comment no. 18.

30. On paragraph 4.4.2, 5) after current add "auxiliary and resistance between cell and fixture". After "oscillograph" add "and data acquisition system at 15 second minimum scan intervals."

31. On paragraph 4.4.3 - see above comment no. 26.

32. On paragraph 4.5.2, 2) supply mounting details, including detailed photographs.

33. On paragraph 4.5.2, 4) - see above comment no. 19.

34. On paragraph 4.5.2, 5) - see above comment no. 30.

35. On paragraph 4.5.2, 6) - see above comment no. 25.

36. On paragraph 4.5.3 - see above comment no. 26.

37. On paragraph 4.6 prior to 1) add "1) conditioning test per paragraph 3.6.3." Replace "1)" by "2)" and replace "2)" by "3)".

38. On paragraph 4.6, add to end of paragraph - "The cell's pressure gage and the cell auxiliary resistor shall be attached to the cell during all of the electrical tests."

39. On paragraph 4.6 - add another paragraph - "Visual inspection - The cell will be visually inspected for defects. Any defects noted will be recorded and close-up photographs showing details will be taken."

40. Add "paragraph 4.7 -
Cell Dissection - After completion of the cell's environmental and functional tests specified herein the cell(s) will be dissected and examined for mechanical integrity. Specific emphasis on the integrity of all weld joints, terminal seals, electrode mechanical integrity, electrode tab position (distortion), separator and case liner position and condition, loose particle presence and position, etc. Detail photographs of all components and microphotographs of all possibly damaged or degraded components will be taken and supplied with the test report."

41. On Figure no. 1 - Include auxiliary signal voltage, thermocouple and data acquisition system (instead of voltmeter).

42. On Figure no. 2 - see comment no. 41.

43. On Figure no. 3 - Eagle picher is hereby requested to furnish fixture details to Grumman prior to start of these environmental tests. Specifically required are:

a) Fixture material and dimensions.
b) Hardware - quantity and type.
c) Mounting provisions to shaker.
d) How is the require 6000 lbs. cell restraining force accomplished?

INFO cc:

J. Cioni NASA/MSC
F. Ford NASA/GSFC
T. Hine
R. Mallard GAC at EP
E. Miller
S. Orehosky
R. Sablich
W. Thomas
R. Wannamaker
M. Wertheim
A. Winegard/B. Lijoi

GRUMMAN AEROSPACE CORPORATION

AVOID VERBAL ORDERS

APPENDIX M-1

FROM	S. Gaston	553/POD	35	9142	DATE 4/19/72
	NAME	GROUP NO. & NAME	PLANT NO.	EXT.	
TO:	J. Rogers E. Carr/W. Harsch				NO. D559-2-15

SUBJECT: 100 AH BATTERY DEVELOPMENT PROGRAM - FINALIZED ENCIRONMENTAL TEST PROCEDURE

Reference:
a) Contract NAS 9-11074
b) Grumman PO #015161
c) Eagle-Picher qual. test procedure QTP-169
d) Grumman AVO D559-2-8, on Approval and Comments on EP Qual. Test Procedure QTP-169
e) EP Comments on Grumman AVO D559-2-8 listed in EP letter dated 4/4/72.

Enclosure: Eagle Picher letter, dated April 4, 1972

PURPOSE:

It is the purpose of this AVO to resolve the Eagle-Picher exceptions taken to the above reference d) document. (This exceptions are shown in the attached enclosure). All of these exceptions were subsequently discussed and commonly resolved per telecon on 4/17/72 between S. Gaston and W. Harsch.

FINALIZED TEST PROCEDURE:

The below listed comments plus the EP document (shown in the attachment), the Grumman AVO D559-2-8 and the EP qual test procedure QTP-169 will form the approved applicable test procedure for the environmental tests for development cells S/N 33 and 44 (or designated alternate cells).

Below listed are the commonly telecon resolved items in reference to the EP exceptions listed in the attachment:

1. EP comments 5, 10, 18 - Acceptable.
2. EP comment 15 - Acceptable, however, the second paragraph of item 15 of above referenced d) document, except for the sixth sentence on "Thermocouple Mounting", is also applicable.
3. EP comments 19, 23 and 33 - Auxiliary signal is to be measured and recorded. The insulation resistance shall be measured and recorded between each environmental test, as a minimum. The insulation resistance measurement during the env. test is desirable, but not required.
4. EP comment 20 - Input and response accelerometers will be recorded (no double run is required, one set of data will be recorded on tape and played back after the run).

5. EP comment 21 - Scanner and 10 second burst are acceptable.
6. EP comment 24 - Acceptable. Eliminate "120 degrees of freedom" Requirement (no 45 minute runs).
7. EP comments 26, 31 and 36 - Same as comment 3 above - The phenolphthalein leak test is to be included.
8. EP comments 30 and 34 - Same as above comments 1 and 3.
9. Clarification - All electrical cell data shall either be recorded on the CEC system (for environ. runs) or on the HLS data acquisition system (for other charges or discharges - equal time recording intervals shall be selected for ease of data reduction of the tape output).

INFO cc:

J. Cioni
F. Ford
T. Hine
R. Mallard
E. Miller
G. Orehosky
R. Zablich
W. Thomas
R. Wannamaker
M. Wertheim
N. [illegible]gard/B. Lijoi

rec'd APR 1 1 1972

EAGLE-PICHER

EAGLE-PICHER INDUSTRIES, INC.

ELECTRONICS DIVISION • P.O. BOX 47, JOPLIN, MISSOURI 64801

4 April 1972

Grumman Aircraft Engineering Corporation
Bethpage, Long Island, New York 11714

Attention: Mr. Jack Rogers
Plant 25

Subject: Schedule for the Construction & Testing of the Parametric Cells

Reference:
a) Contract NAS9-11074
b) Grumman P.O. #015161
c) Grumman AVO D559-2-8, Dated 3/22/72
d) " AVO D559-2-2, Dated 1/26/72
e) " AVO D559-2-2A, " 2/23/72
f) " AVO D559-2-6, " 2/28/72
g) " AVO D559-1-24, " 8/20/71
h) " AVO D559-2-9, " 3/27/72

Gentlemen:

In response to the above Ref. h, Grumman AVO and to avoid any further schedule delay, the following action will be taken:

1. Environmental Tests on the Present Design Cells (Ref c)

Eagle-Picher has received GAC comments on QTP-169, Environmental Test Procedure. All changes have been made with the exception of the following:

<u>Comment No. (Ref c)</u>

5 Instead of replacing 4.0 with 4.3.2, "of this procedure" has been added to this paragraph.

10 Paragraph 3.2 f, g, h are tolerances for the measurements taken, regardless of the system used.

15 In response to this comment, the following procedure for Paragraph 4.2.2 is presented.

1) Verify that the cell pressure gage and auxiliary electrode resistor has been removed and the cell resealed with a plug.

2) Mount the cell in the fixture as shown in Figure 3.

3) Conduct an electrical insulation resistance check between cell and fixture. The minimum acceptable resistance using

a 50 VDC source shall be 50 mega-ohms.

4) Connect the cell to charge panel, E-P Test Aid #1, Figure 1 and charge at 30 amps for 5 hours or to a cell voltage of 1.50 volts, whichever comes first.

5) Subject the cell to, etc.

18 The requested discharge time has been incorporated, however, the data acquisition system will not be used for this part of the test. A continuous CEC recorder is being used. Additional recording would be a duplication and require additional personnel to conduct the test.

19 This change has not been made. Recording the auxiliary electrode voltage without the resistor installed and the insulation resistance between cell case and fixture would require additional recording equipment and does not provide meaningful data as to the effect of vibration on the cell.

20 The vibration equipment being used can only plot one accelerometer at a time, therefore, to plot both input and response, the test would have to be run twice.

21 Normal verification of test tolerances for random vibration is done visually by reading each 50 cycle bandwidth channel meter. A plot can be made of the input by using a scanner. If this scanner is used, it will require at least a 30 second burst and will measure the average power per each 50 cycle bandwidth. To conduct an analysis of the continuous frequency spectrum, it would mean using a tracking filter and recording on magnetic tape. This tape would then have to be fed back through the X-Y plotter to get a continuous power spectral density. It is recommended that we use the scanner and 30 second bursts.

23 Same as Comment 19.

24 Same as Comment 21 and, in addition, 120 degrees of freedom would require a run of 45 minutes/axis.

26 Same as Comment 19. The phenolphthalein leak test has been added.

30 Same as Comment 18 & 19

31 Same as Comment 26

33 Same as Comment 19

34 Same as Comment 30

36 Same as Comment 26

If approval is granted for QTP-169 with the above exceptions, the Environmental Tests will be completed during the month of April.

2. Mechanical Solutions on the Auxiliary Electrode Tab-to-Can Weld and Finalization of Cell Drawings (Ref. d & g)

Eagle-Picher has reviewed the findings and recommendations listed in Grumman AVO D559-2-2, dated 1/26/72. The method presently being used to attach the auxiliary electrode to the cell container has been a standard method at Eagle-Picher since the conception of auxiliary electrodes. No cell failure has ever been caused by the auxiliary tab shorting to the storage electrodes. A problem of keeping the auxiliary tab from bending during final cell closure does exist, however, this can be controlled by X-raying the cell before welding the cover. If the tab is shown to be bent, the internal cell pack can be removed and the electrode repositioned. An X-ray after welding will verify that the electrode is properly attached.

GAC preferred design (Ref d) requires the welding of a small stainless steel tab on a flat surface of the cover. This type of welding is very difficult and presents a possible leak path. Also, this design does not eliminate the possibility of the auxiliary electrode moving causing a bend in the auxiliary tab. The alternate design presents the problem of spotwelding dissimilar materials and does not eliminate the possibility of the auxiliary electrode moving during final cell closure.

Eagle-Picher recommends that the present method be used, but that tighter controls during installation be used. Also that X-rays be made of this important area.

Cell drawings reflecting GAC comments (Ref g) have been completed and submitted.

3. Submittal of Electrode Construction and Control Data

All cell data has been submitted to GAC. If additional data is needed, please specify the specific data required.

4. Schedule of terminal construction and date when samples will be submitted to Grumman for analysis.

Ceramaseal is to make a few seals for test beginning on 3/31/72. Delivery of these seals will be immediately thereafter. Terminal construction will begin after approval of samples.

5. Updating of Ratio Test Plan and Submittal to Grumman (Ref f)

   The updated ratio test procedure will be submitted by 4/7/72.

6. Submittal of an updated Quality Assurance Plan.

   The updated quality assurance plan will be submitted by April 7.

7. Submittal of the Cell Acceptance Test Plan

   The Acceptance Test Plan (ATP-251) will be resubmitted by April 7.

8. Cell Construction, Test and Delivery Dates for Both Cell Groups

   A schedule for the parametric test cells is included in this letter. The schedule for the remaining cells is based on the amount of time required to test the parametric cells at GAC.

Very truly yours,

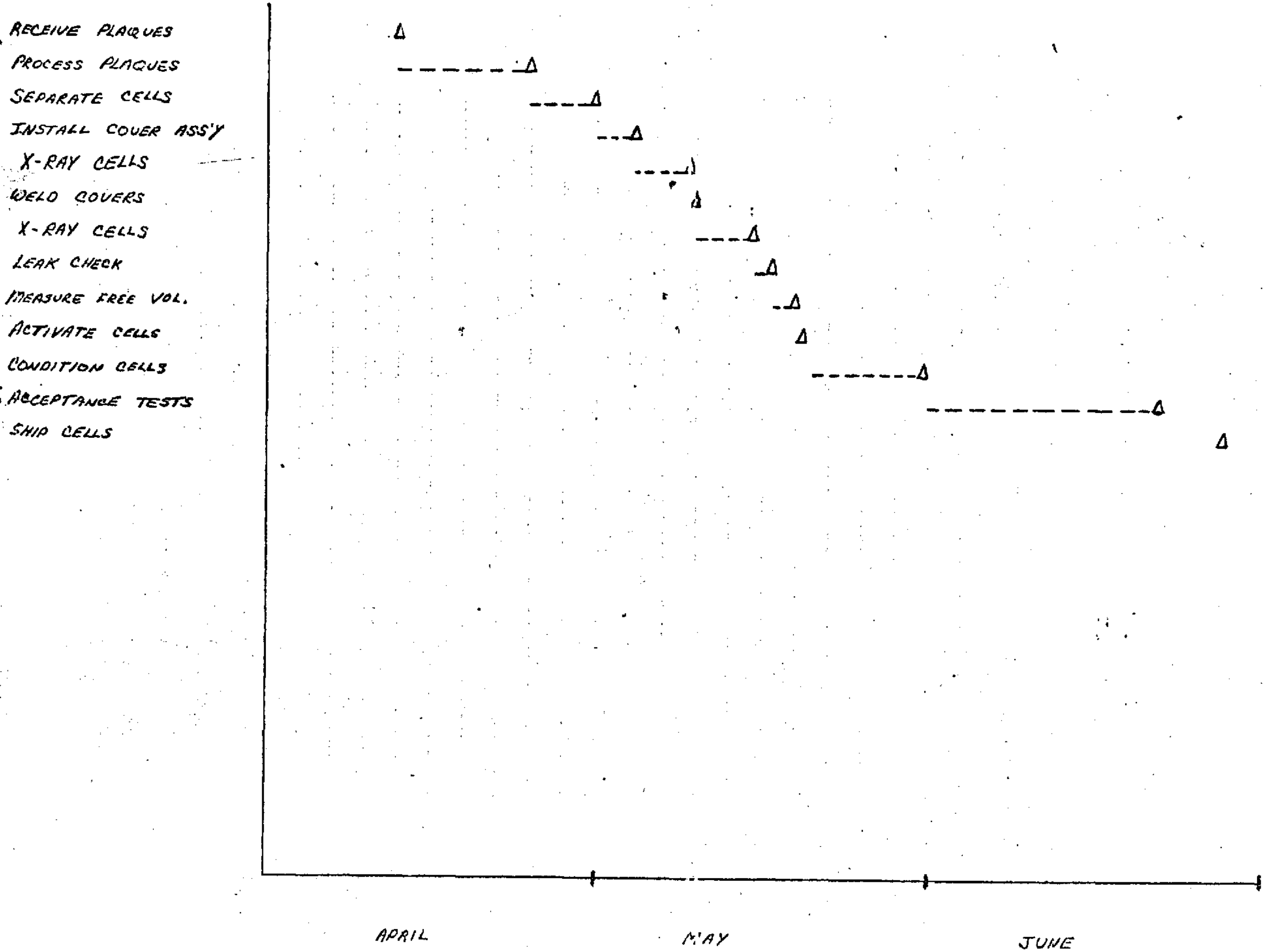
William C. Harsch

William C. Harsch
Project Engineer

WCH/bd

cc: J. Cioni
F. Ford
S. Gaston
A. Cook
E. Carr
J. Dines

SCHEDULE FOR 27ea. RSN 110 PARAMETRIC TEST CELLS



APPENDIX M-2

DATAFAX

5 July 1972

To: Jim Cioni, EP-5
NASA/MSC
(Manned Spacecraft CTR.)
Houston, Texas 77058

Steve Gaston x 2741
GAC
POD Section Pl. 35
Bethpage, L. I., New York 11714

Subject: Environmental Testing of RSN-110 Cells S/N 33 & 44
Contract No. 0-15161
Prime Contract NAS 9-11074

Environmental testing of RSN-110 cells S/N 33 & 44 began on 6/21/72 per Eagle-Picher Test Procedure, QTP-169.

S/N 33 was the first cell to be vibrated. The vibration levels were 0.5 inch D.A. for 5-35 Hz and 30 g's for 35-2000 Hz. The cell was discharged at 50 amps during vibration and a continuous recording was made of the terminal voltage, current and auxiliary electrode voltage (without load resistor). During the first axis (X-X') of sine vibration, the recording shows an erratic auxiliary electrode voltage for approximately 30 seconds at about 150 Hz at 30 g's. Everything else appeared normal during this axis. The Y-Y' axis ran normally with the exception of spikes on the auxiliary electrode voltage at 1.5 minutes into the discharge. During the Z-Z' axis of sine vibration, the cell terminal voltage had a sharp drop from 1.20 volts to 1.16 volts between 900 and 1000 Hz. The auxiliary electrode voltage also showed this decrease. It was decided not to run random vibration on this cell.

S/N 44 was vibrated next and appeared normal through both sine and random vibration.

After vibration, both cells were cycled to verify capacity. S/N 33 delivered 40 ampere-hours and S/N 44, 102 ampere-hours. The cells were then X-rayed to try to determine the reason for the capacity losses. The cells were x-rayed through all corners and edges and in the area of the auxiliary electrode. No abnormalities could be seen on the X-rays with the exception of the auxiliary electrode tabs being slightly bent. With GAC concurrence, S/N 33 was opened and visually examined. All but 4 plates showed degrees of breakage. All the plate damage was confined to the tab area. The plate-to-tab welds were intact but the plates were torn just below the tab welds. Everything else in the cell appeared normal. S/N 44 was not opened, but it is believed that this cell is in the same condition but at a lesser degree.

It is our conclusion that the 30 g sine vibration level is excessive and that this cell design cannot withstand these levels without a major redesign. We recommend that a review be made of the vibration requirements for the purpose of lowering the levels.

No further action is planned on these cells until Eagle-Picher and Grumman Engineering have completed the analysis and concurred on a plan of action.

William C. Harsch

Page 1 of 1

GRUMMAN AEROSPACE CORPORATION

AVOID VERBAL ORDERS

APPENDIX M-3

FROM	NAME	GROUP NO. & NAME	PLANT NO.	EXT.	DATE
	M. Wertheim/W. Thomas	553/POD	35	9142	7/6/72

TO:

J. Rogers, Subcontracts
W. Harsch/E. Carr, Eagle-Picher

NO. D559-2-29

SUBJECT: QUALIFICATION VIBRATION LEVELS

Reference: a) Contract NAS 9-11074
b) Grumman PO 0-15161
c) Eagle Picher "Environmental Test Procedure for Eagle-Picher Cell RSN-110", QTP-169
d) Telecons: S. Gaston/M. Wertheim with W. Harsch/E. Carr, 6/22/72 through 7/5/72

Pursuant to the reference d) telephone conversations relating to failures on cell S/N 33 during sinusoidal vibration, please revise the reference c) test plan as follows:

1. Para. 4.2.2-5) -- change levels as follows:

"Frequency Range (Hz)	Acceleration (0 to peak)
5-14	0.5 in D.A.
14-100	±5 g
100-200	±10 g
200-2000	±15 g

Sweep frequency at a rate of two (2) octaves per minute."

2. Para. 4.3.2 - 1) -- Add to existing levels the following:

"Increase levels above by 4 db for 30 seconds per axis in all three (3) axes"

3. Paragraphs 4.3.3, 4.4.3, 4.5.3 -- Add the following:

"At the end of test, the cell shall be fully discharged. The cell shall then be subjected to a capacity test in accordance with ATP-251, para. 4.8.5.1 through 4.8.5.3, as approved by GAC AVO D559-2-28, dated 6/29/72."

The above shall be used to test cell S/N 36, and any or all cells hereafter subjected to the tests of QTP-169.

S. J. Gaston
S. J. Gaston, Project Engineer

INFO cc:

J. Cioni	S. Orehosky
F. Ford	R. Sablich
T. Hine	R. Wannamaker
E. Miller	

GAC 377 REV. 4

APPENDIX M-4

SINGLE CELL DISCHARGE DATA 1 of 4

START TIME ______

DATE 2-13-72 OPER. [illegible] BAT. TYPE CSH 110 JOB NO. ______

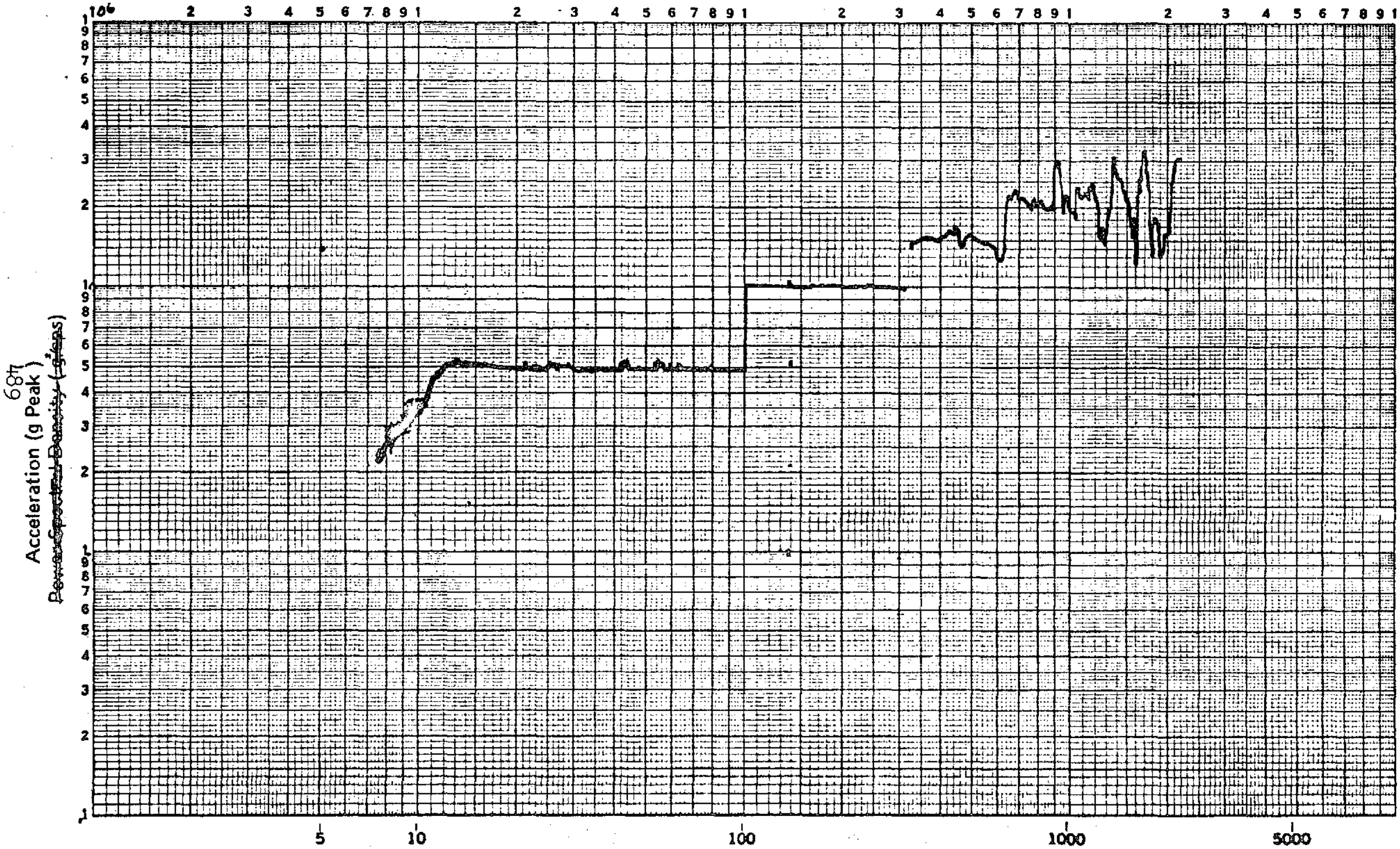
CELL NO. 35

	TIME	[illegible]	Aux	Amps	AMP-MIN			
	OCV	1.357	.550	0				
	1 min	1.303	.552	50				
	2 "	1.292	.555	"				
	3 "	1.286	.554	"				
	4 "	1.299	.553	"				
X-X'	5 "	1.273	.551	"				
AXIS	6 "	1.267	.550	"				
	7 "	1.284	.547	"				
	8 "	1.261	.548	"				
	9 "	1.258	.550	"				
	OCV	1.312	.574	0				
	1 min	1.257	.548	50				
	2 "	1.251	.548	"				
Y-Y'	3 "	1.249	.548	"				
	4 "	1.247	.547	"				
AXIS	5 "	1.246	.547	"				
	6 "	1.244	.543	"				
	7 "	1.244	.548	"				
	8 "	1.243	.549	"				
	9 "	1.243	.550	"				
	OCV	1.297	.572	0				
	1 min	1.242	.548	50				
	2 "	1.243	.547	"				
	3 "	1.242	.548	"				
Z-Z'	4 "	1.241	.549	"				
	5 "	1.241	.548	"				
AXIS	6 "	1.241	.485	"				
	7 "	1.241	.549	"				
	8 "	1.241	.554	"				
	9 "	1.241	.554	"	1350 =	22.5 A-H		
	OCV	1.309	—	0				
FINAL	1 MIN	1.241		50				
DISCH	5 MIN	1.237		"				
	15 MIN	1.237		"				
	30	1.235		"				
	45	1.231		"				
	60	1.226		"				
	75	1.220		"				
	90	1.209		"				
	105	1.192		"				
	~~120~~							
	118:41	1.000		"	5935 =	98.9		171.4
	119:20	0.960			~~[illegible]~~ 3.5 =	6.6		172

CELL NUMBER — BAT. NUMBER
NO. OF PLATES POS./NEG.
POSITIVE - FORM. NO.
PL. WT. - THICKNESS
TYPE GRID - PL. SIZE
NEGATIVE - FORM. NO.
PL. WT. - THICKNESS
TYPE GRID
SEPARATION TYPE
ELECTROLYTE TYPE
DRY WT. — WET WT. (gms.)
SYRINGE FILLED cc/Cell
VACUUM - Inches Filled - Drain cc/Cell
HRS. ON STAND - TEMP. °F
DISCHARGE - RATE - TEMP. °F
MINS. TO VOLTS
VOLTS
AMPS.
VARIABLE

EAGLE-PICHER INDUSTRIES, INC.

ELECTRONICS DIVISION
COUPLES DEPARTMENT



Job No. .... Item RSN 110 .... Serial No. 35 .... Date 7-12-72 .... Time 1040

Axis & Condition X- Response .... Pickup S/N & Location 2B-29 .... Pickup Sensitivity 10 mv rms / g rms

Overall mv rms NA = NA g rms   Analyzer Calibration NA g²/cps   Sweep Speed .54 Decades/min. .... cps/sec

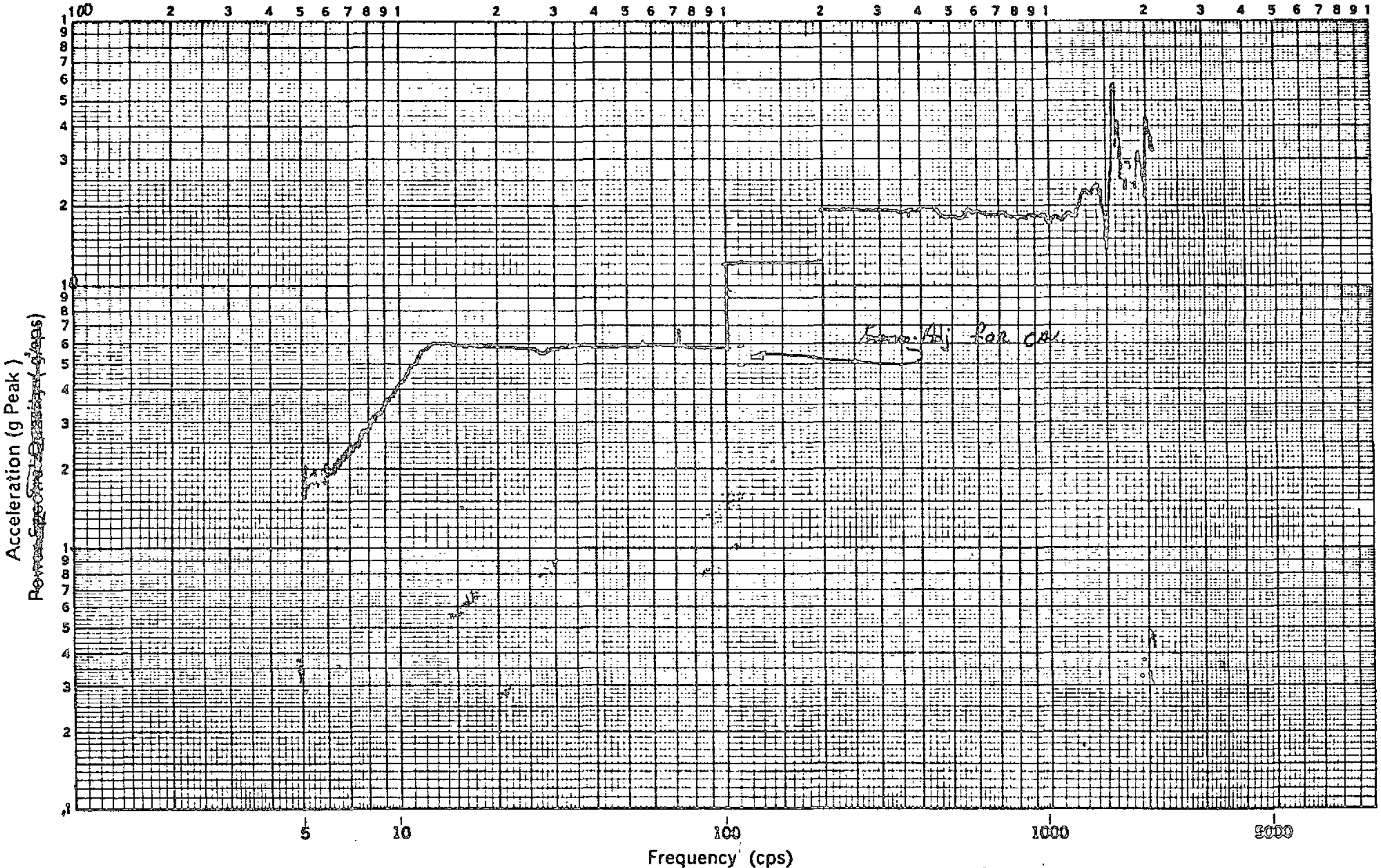
Analyzer Filter NA cps BW   Multiplier NA   Range NA   Avg.Time NA Sec.   Operator [signature]

Sheet 2 of 4

EAGLE PICHER

EAGLE-PICHER INDUSTRIES, INC.

ELECTRONICS DIVISION
COUPLES DEPARTMENT



Job No. .... Item RSN 110 .... Serial No. 35 .... Date 7-13-72 .... Time ....

Axis & Condition Y-Response .... Pickup S/N & Location 4B-29 .... Pickup Sensitivity 10.57 $\frac{\text{mv rms}}{\text{g rms}}$

Overall mv rms NA = NA g rms Analyzer Calibration NA .... g²/cps Sweep Speed .554 Decades/min .... cps/sec

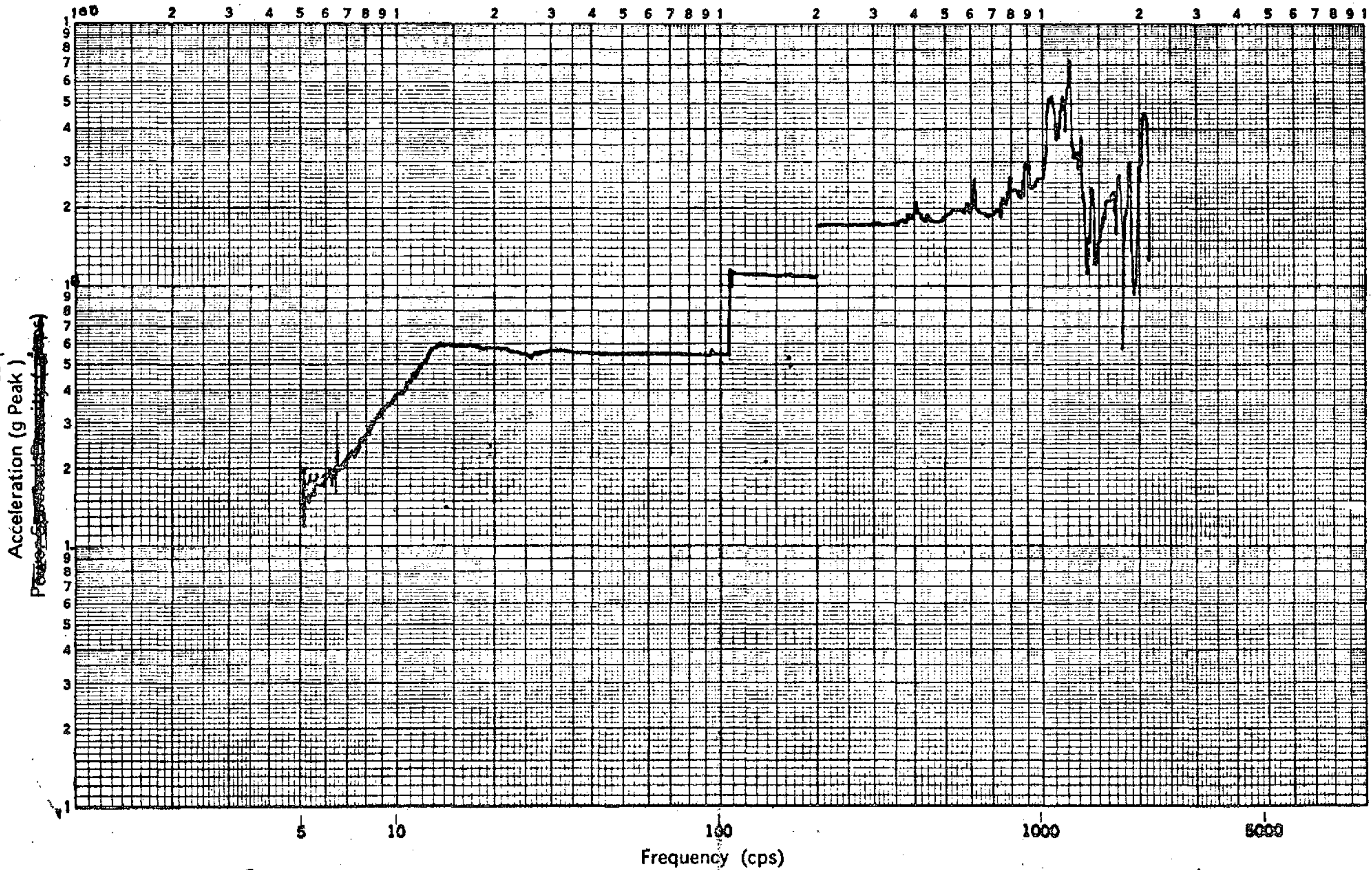
Analyzer Filter NA cps BW Multiplier NA Range NA Avg. Time NA Sec. Operator [signature]

TF – 100 – 2695

EAGLE PICHER

EAGLE-PICHER INDUSTRIES, INC.

ELECTRONICS DIVISION
COUPLES DEPARTMENT



Job No. .... Item RSN 110 .... Serial No. 35 .... Date 7-13-70 .... Time 11:15

Axis & Condition Z- Response .... Pickup S/N & Location LB-29 .... Pickup Sensitivity 10 mv rms / g rms

Overall mv rms NA = NA g rms Analyzer Calibration NA g²/cps Sweep Speed .54 Decades/min .... cps/sec

Analyzer Filter NA cps BW Multiplier NA Range NA Avg.Time NA Sec. Operator [signature]

Sheet 4 of 4

491

APPENDIX M-5

START TIME

SINGLE CELL DISCHARGE DATA

DATE 7-13-73 OPER. [illegible] BAT. TYPE [illegible] JOB NO.

	CELL NO. →	36		
	TIME	Vcell	Acx	AMPS
START VIBRATION	OCV	1.379	.626	0
	1 MIN	1.323	.597	50
	2 "	1.313	.592	"
	3 "	1.305	.589	"
	4 "	1.298	.587	"
	5 "	1.292	.586	"
X-X' AXIS	6 "	1.287	.590	"
	7 "	1.282	.585	"
	8 "	1.278	.584	"
	9 "	1.274	.584	"
	OCV	1.322	.614	0
	1 MIN	1.273	.588	50
Y-Y' AXIS	2 "	1.268	.585	"
	3 "	1.264	.584	"
	4 "	1.261	.584	"
	5 "	1.258	.583	"
	6 "	1.257	.586	"
	7 "	1.255	.585	"
	8 "	1.253	.585	"
	9 "	1.252	.585	"
	OCV	1.304	.616	0
	1 MIN	1.254	.589	50
	2 "	1.250	.588	"
	3 "	1.248	.588	"
Z-Z' AXIS	4 "	1.247	.588	"
	5 "	1.247	.589	"
	6 "	1.246	.597	"
	7 "	1.246	.592	"
	8 "	1.245	.592	"
	9 "	1.245	.592	"

ΣCAP = 114 AMP-HR

CELL NUMBER — BAT. NUMBER
NO. OF PLATES POS./NEG.
POSITIVE - FORM. NO.
PL. WT. - THICKNESS
TYPE GRID - PL. SIZE
NEGATIVE - FORM. NO.
PL. WT. - THICKNESS
TYPE GRID
SEPARATION TYPE
ELECTROLYTE TYPE
DRY WT. — WET WT. (gms.)
SYRINGE FILLED cc/Cell
VACUUM - Inches Filled - Drain cc/Cell
HRS. ON STAND - TEMP. °F
DISCHARGE - RATE - TEMP. °F
MINS. TO VOLTS
VOLTS
VARIABLE
AMPS.

FORM TF 12 Musselman's Litho

START TIME

SINGLE CELL DISCHARGE DATA

DATE ______ OPER. ______ BAT. TYPE ______ JOB NO. ______

RANDOM VIBR.

CELL NO. →	36			
TIME	Vcell	Aux	AMPS	
Z-Z' AXIS				
CCV	1.324	.619	0	
1 MIN	1.251	.591	50	
2 MIN	1.246	.589	"	
3 "	1.244	.596	"	
4 "	1.242	.597	"	
5 "	1.241	.598	"	
6 "	1.241	.600	"	
7 "	1.241	.597	"	
8 "	1.241	.595	"	
Y-Y' AXIS				
CCV	1.294	.628	0	
1 MIN	1.246	.602	50	
2 "	1.243	.601	"	
3 "	1.241	.606	"	
4 "	1.241	.608	"	
5 "	1.241	.608	"	
6 "	1.240	.610	"	
7 "	1.240	.610	"	
8 "	1.240	.608	"	
X-X' AXIS				
CCV	1.292	.624	0	
1 MIN	1.244	.599	50	
2 "	1.241	.599	"	
3 "	1.240	.603	"	
4 "	1.239	.604	"	
5 "	1.239	.605	"	
6 "	1.238	.606	"	
7 "	1.238	.604	"	
8 "	1.238	.604	"	

DISCH. AFTER VIBR. 7/14

Copied MW

CCV	
5 MIN	1.22
15 "	1.22
30 "	1.22
45 "	1.21
1 HR	1.20
15 MIN	1.18
25 MIN	1.10
26 MIN	1.00

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant - Joplin, Missouri

TYPE TEST: CHARGE FOR SINE VIBRATION   TEST SPECIMEN NO. ____

TEST PROCEDURE NO. ____   DATE 7-13-72   TIME 1040
TEST PARA. REF. NO. ____   E. P. BAT. TYPE RSN-110   S. N. ____
AMBIENT TEMP. ____ °F   ____ BAT. NO. ____
BATT. TEMP. ____ °F   TYPE PROGRAM: PROD. ☐ QUAL. ☐ R & D ☐
PREVIOUS TEST: ____

30 AMP CHARGE

CELL NO 36 PRESS

TIME	VOLTS	AMPS				TIME	VOLTS	AMPS			
O.C.V			.01		0						
1045	5 min		1.41		0						
1140	1 hour		1.41		0						
1240	2 hours		1.41+		1						
1340	3 hours		1.42		2.5						
1440	4 hr		1.44		4.5						
1515	35 min		1.46		8						
1525	45 "		1.48		11						
	Vented 14 psi O_2										

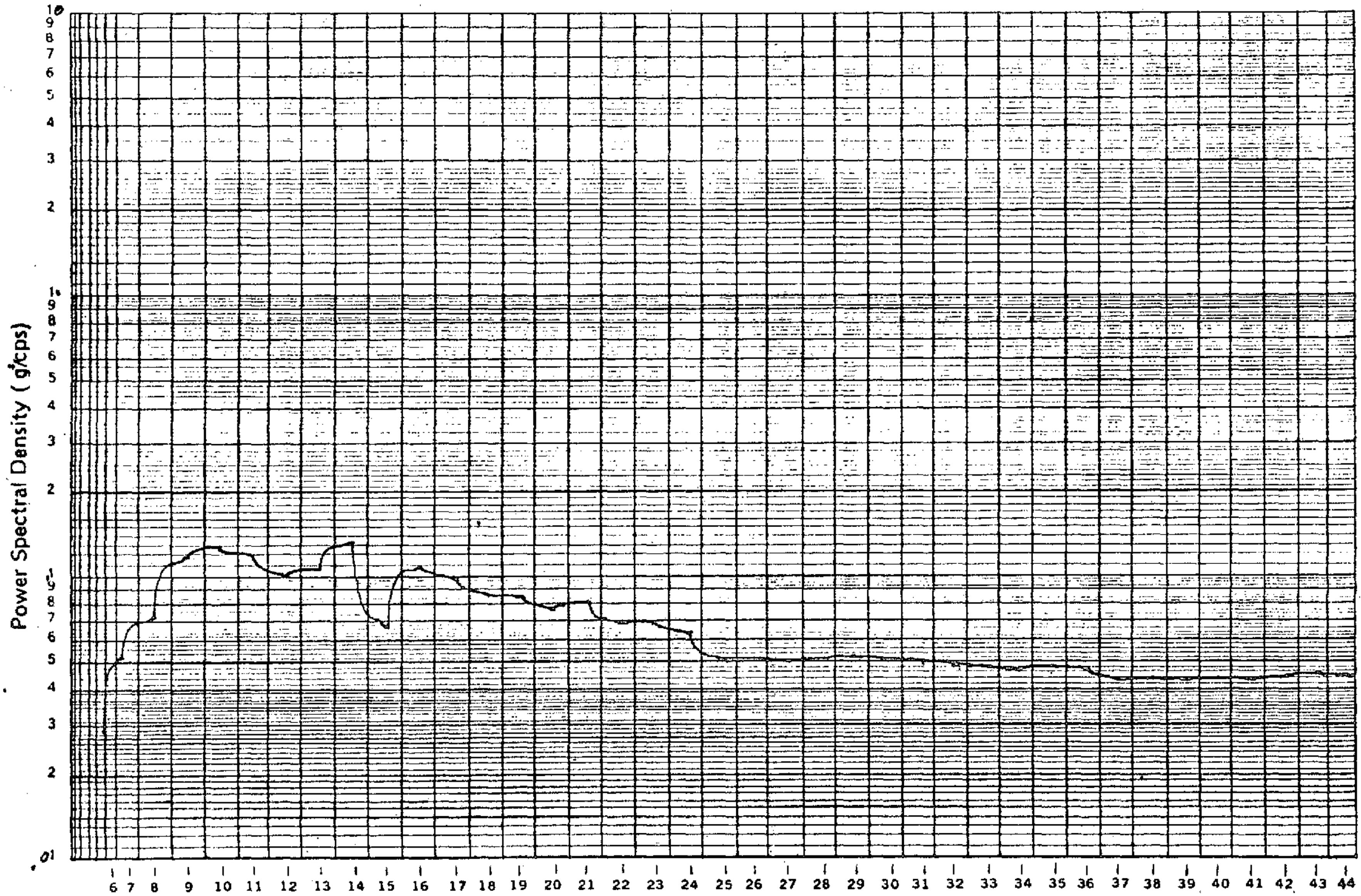
	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

TF-41 WHITAKER PTG 8387

EAGLE PICHER

EAGLE-PICHER INDUSTRIES, INC.

ELECTRONICS DIVISION
COUPLES DEPARTMENT



Job No.............. Item RSN 110 .... Serial No. 36 .... Date 7-13-72 .... Time..............

Axis & Condition Y- Control .... Pickup S/N & Location LB-39 .... Pickup Sensitivity 10 mv rms / g rms

Overall mv rms 120 = 12.0 g rms Analyzer Calibration NA g²/cps Sweep Speed NA Decades/min. .... cps/sec

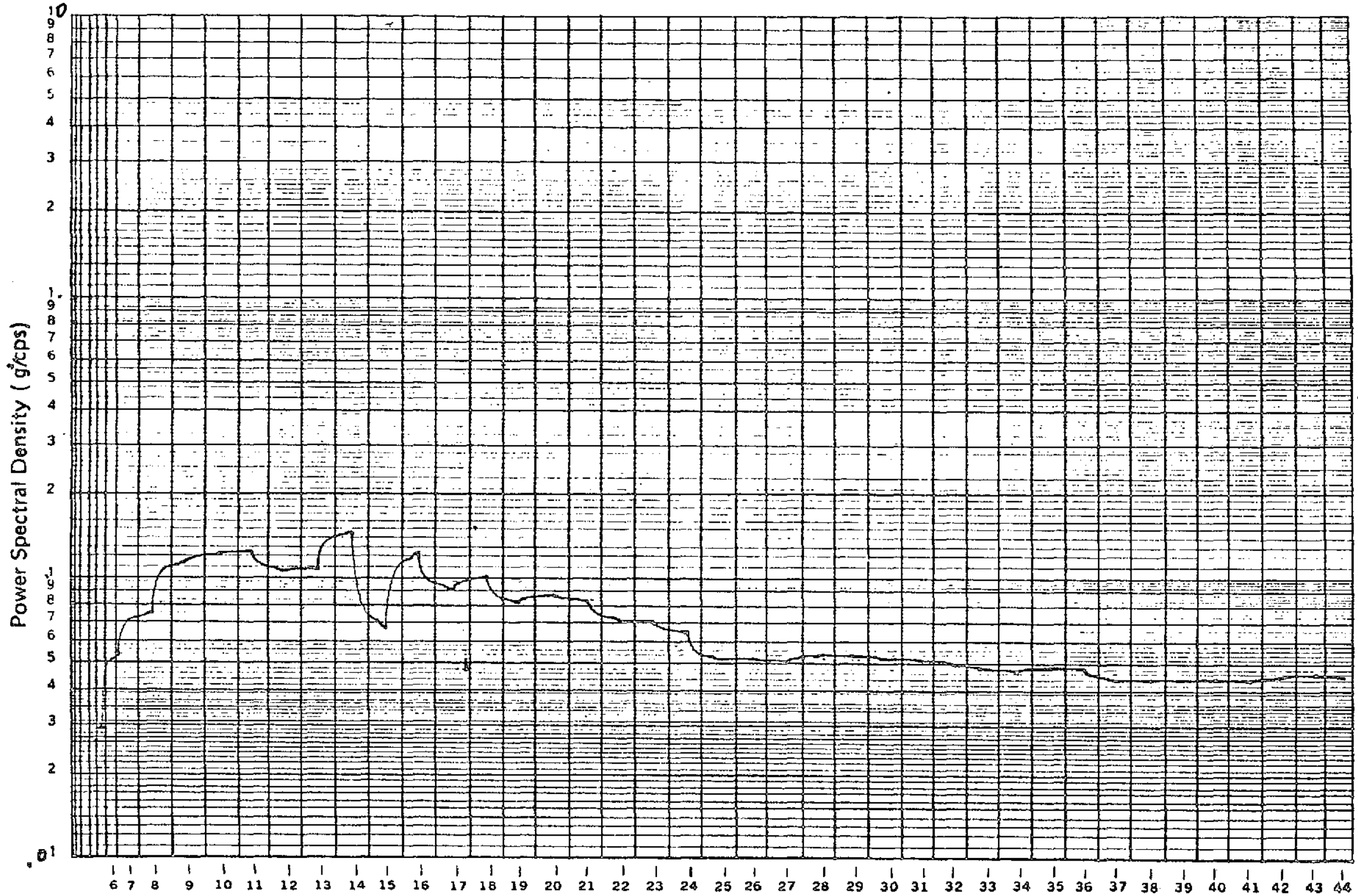
Analyzer Filter NA cps BW Multiplier NA Range NA Avg.Time NA Sec. Operator [signature]

TF-104-469S

EAGLE PICHER

EAGLE-PICHER INDUSTRIES, INC.

ELECTRONICS DIVISION
COUPLES DEPARTMENT



Job No. .... Item RSN110 Serial No. 36 Date 7-13-72 Time 1606

Axis & Condition X- Control Pickup S/N & Location LB-39 Pickup Sensitivity 10 mv rms / g rms

Overall mv rms [illegible]7 = 11.7 g rms Analyzer Calibration NA g²/cps Sweep Speed NA Decades/min ...... cps/sec

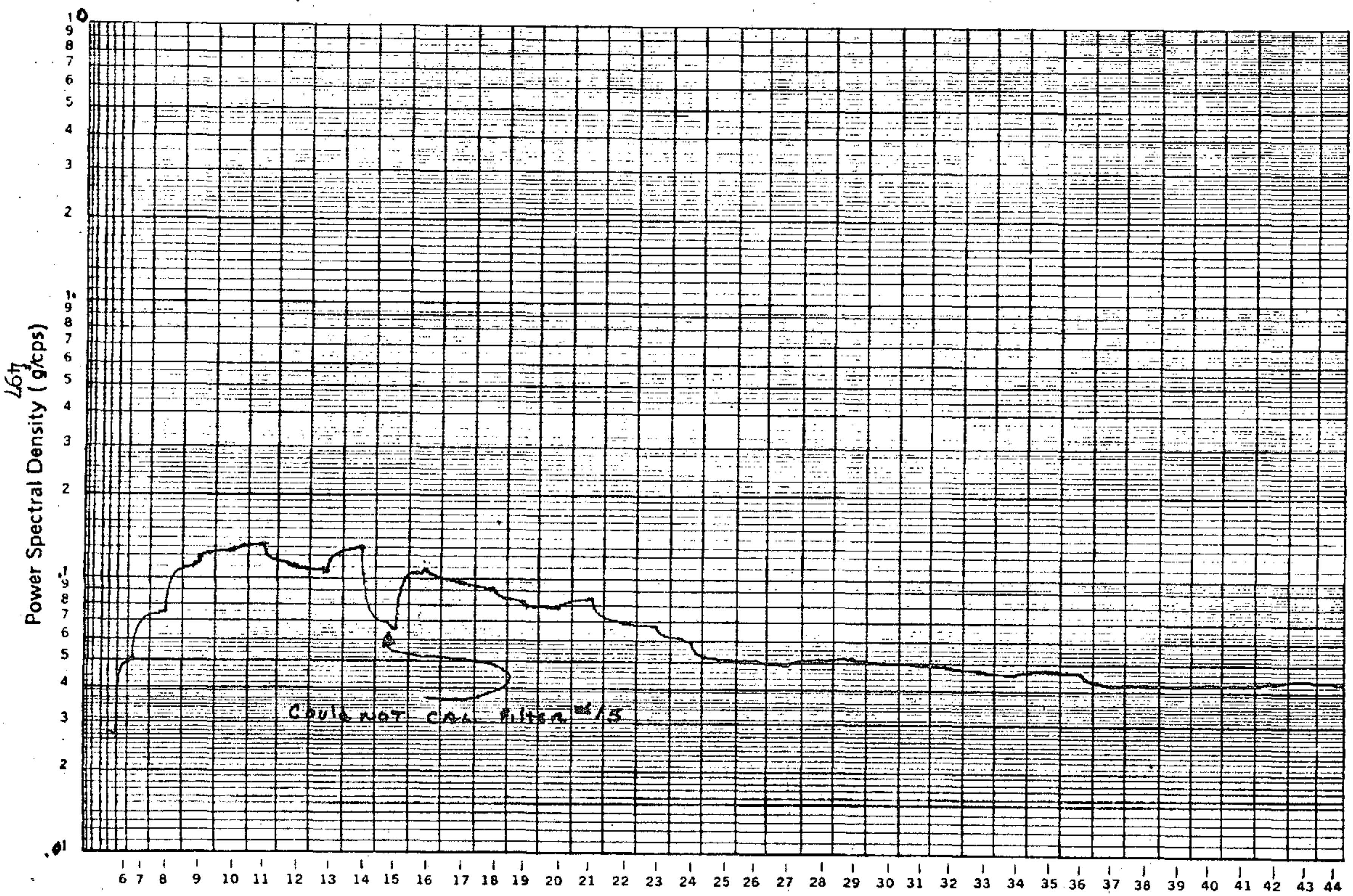
Analyzer Filter NA cps BW Multiplier .... Range NA Avg.Time NA Sec. Operator [signature]

TF-104-469S

EAGLE PICHER

EAGLE-PICHER INDUSTRIES, INC.

ELECTRONICS DIVISION
COUPLES DEPARTMENT



Job No. .... Item RSN 110 .... Serial No. 36 .... Date 7-19-72 .... Time ....

Axis & Condition Z- Control .... Pickup S/N & Location 28-39 .... Pickup Sensitivity 10 mv rms / g rms

Overall mv rms 132 .... = 13.2 g rms Analyzer Calibration NA .... g²/cps Sweep Speed NA .... Decades/min .... cps/sec

Analyzer Filter NA cps BW Multiplier NA Range NA Avg.Time NA Sec. Operator [signature]

TF-104-469S

EAGLE PICHER

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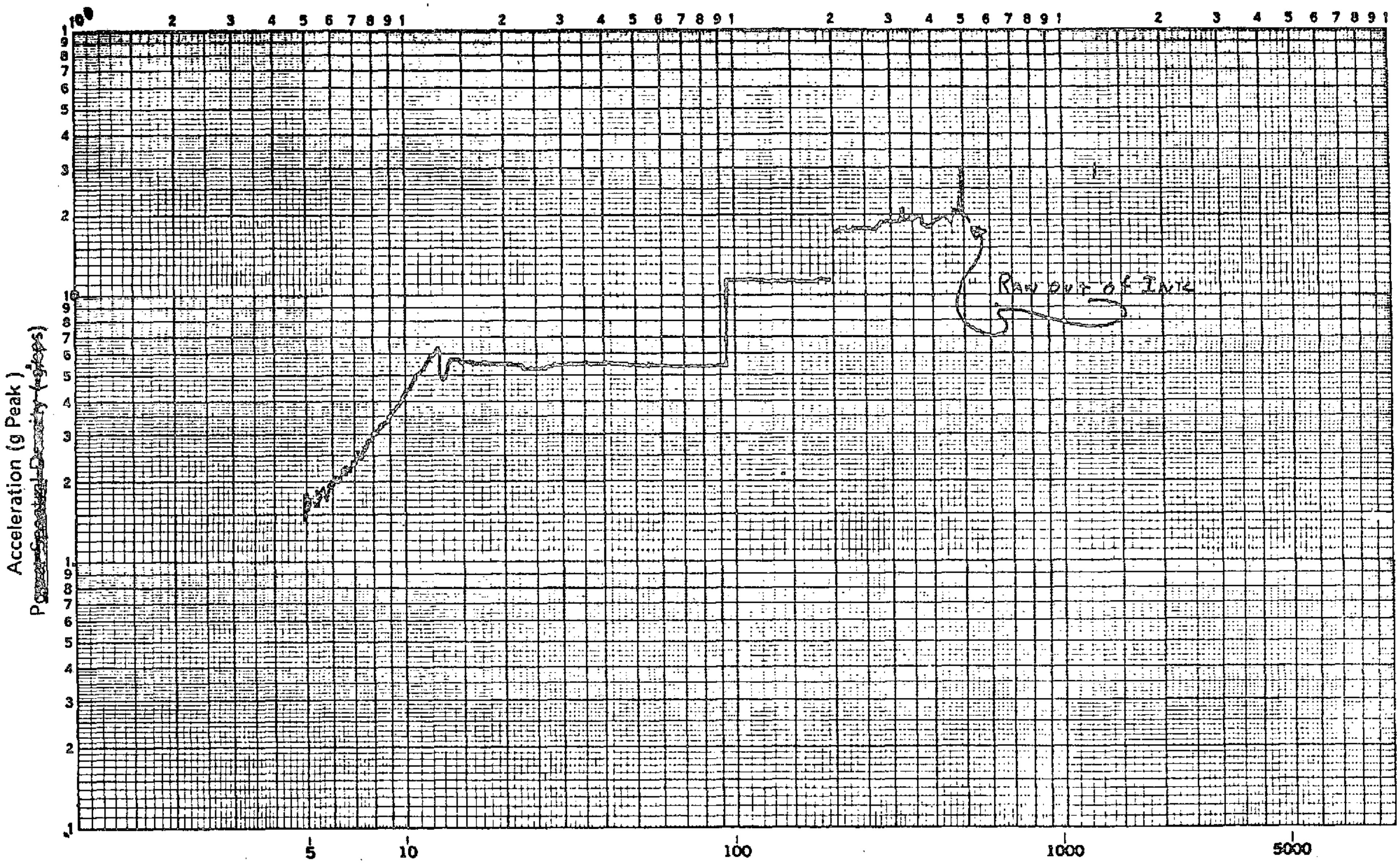
ELECTRONICS DIVISION
COUPLES DEPARTMENT



808

Job No. .... Item RSN110 .... Serial No. 36 .... Date 7-13-72 .... Time 1700

Axis & Condition Z- Response .... Pickup S/N & Location LB-29 .... Pickup Sensitivity 10 mv rms / g rms

Overall mv r ... NA = NA g rms Analyzer Calibration NA .... g²/cps Sweep Speed .54 Decades/min .... cps/sec

Analyzer Filter NA cps BW Multiplier NA Range NA .... Avg.Time NA .... Sec. Operator [signature]

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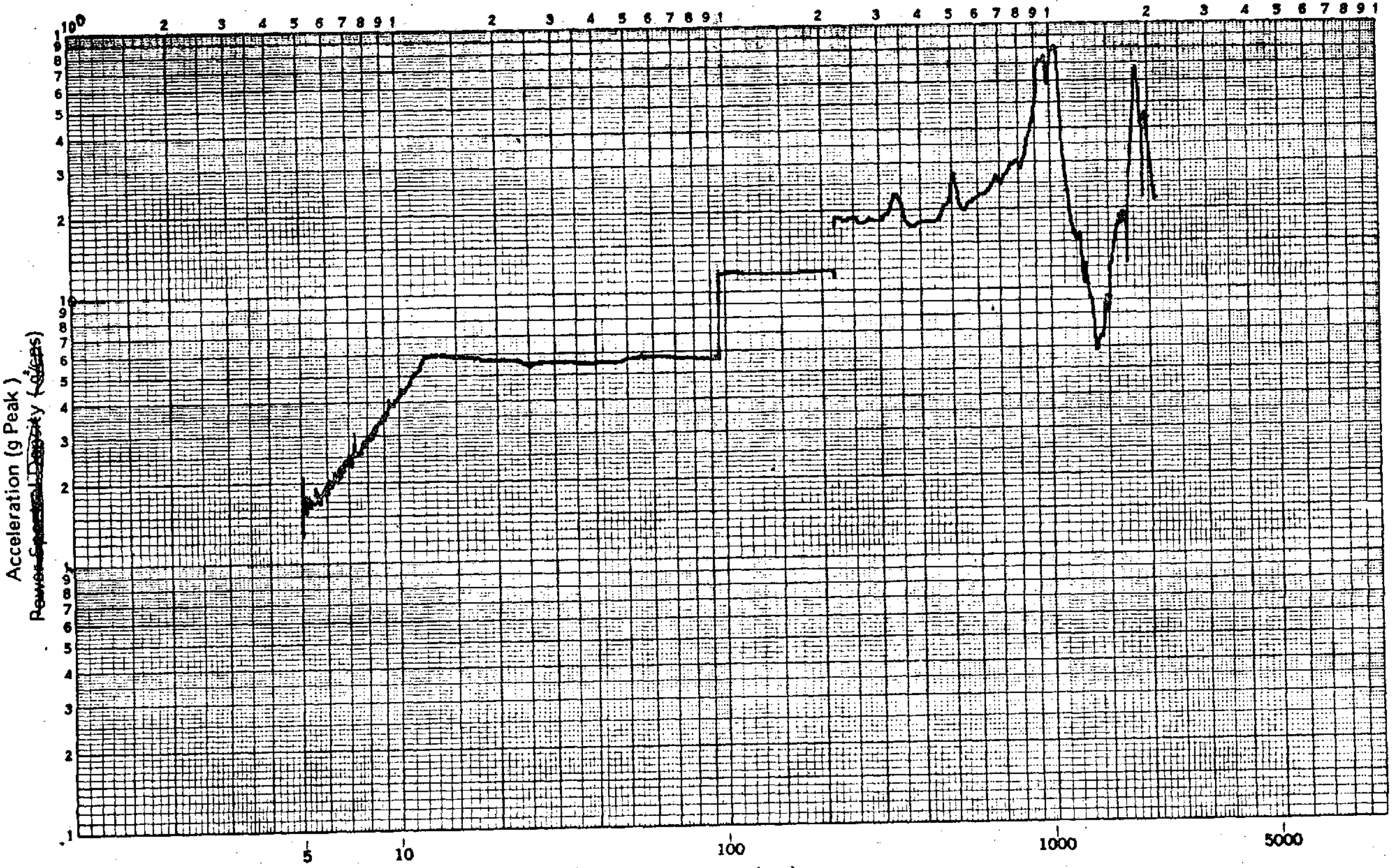
ELECTRONICS DIVISION
COUPLES DEPARTMENT



Job No. .... Item RSN 110 .... Serial No. 36 .... Date 7-13-72 .... Time 1647

Axis & Condition Y- Response .... Pickup S/N & Location LB-29 .... Pickup Sensitivity 10 mv rms / g rms

Overall mv rms NA = NA g rms   Analyzer Calibration NA g²/cps   Sweep Speed .54 Decades/min .... cps/sec

Analyzer Filter NA cps BW   Multiplier NA   Range NA   Avg. Time NA Sec.   Operator

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PICHER

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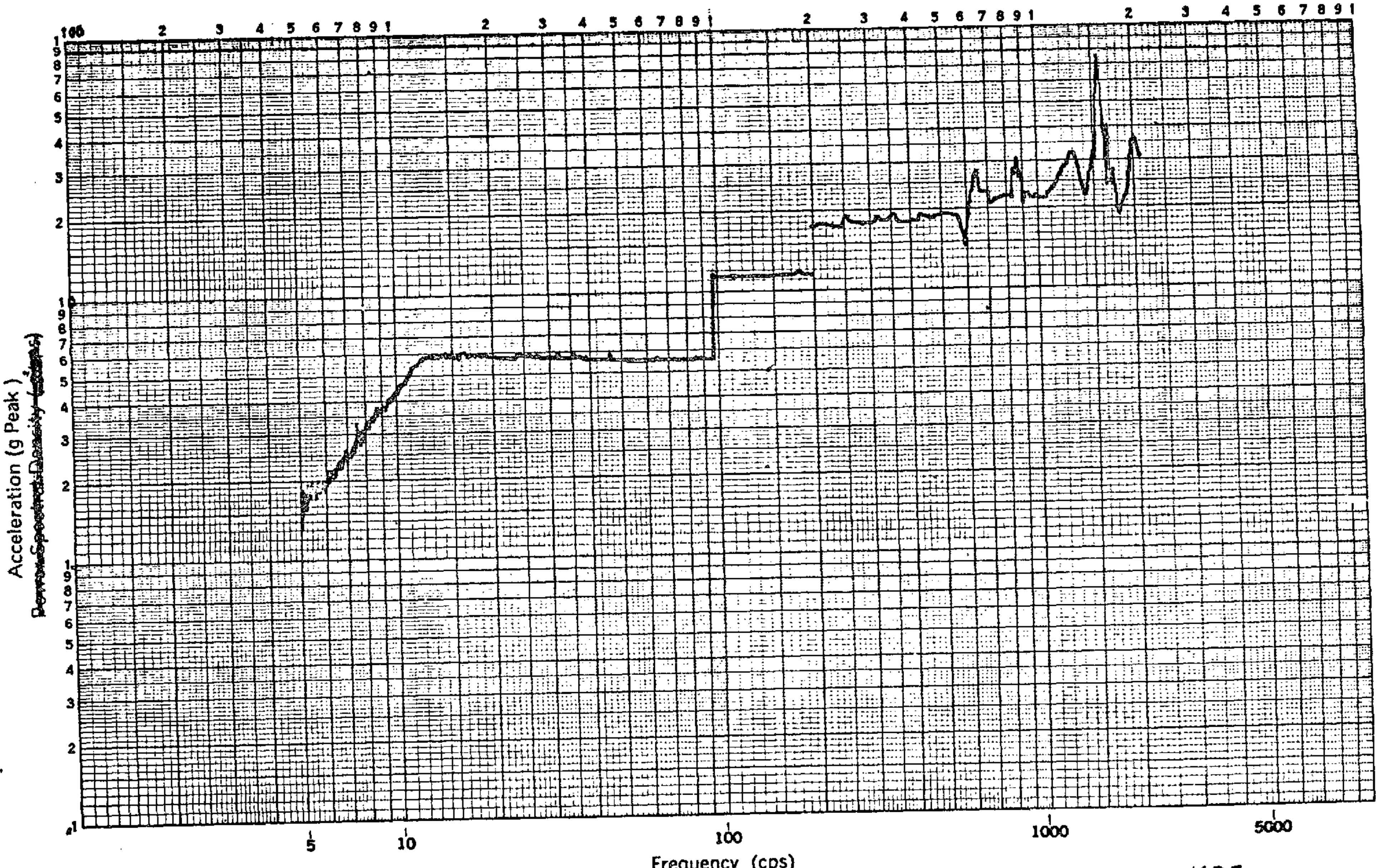
ELECTRONICS DIVISION
COUPLES DEPARTMENT

500



Job No. .... Item RSN 110 .... Serial No. 36 .... Date 7-13-72 .... Time 1635

Axis & Condition X- RESPONSE .... Pickup S/N & Location LB-29 .... Pickup Sensitivity 10 mv rms / g rms

Overall mv r... NA = NA g rms   Analyzer Calibration ... g²/cps   Sweep Speed .54 Decades/min .... cps/sec

Analyzer Filter NA cps BW   Multiplier .... Range NA   Avg.Time NA Sec.   Operator [signature]

APPENDIX N-1

TABULATION OF
CELL DESIGN DESCRIPTION

ITEM NO.	DESIGN GROUP	CELL DESIGN DESCRIPTION	CELL S/N	SEPARATOR TYPE	SEPARATOR NO.	ELECTRODE NO. (+)	ELECTRODE NO. (-)	AUX. ELECTRODE DESIGN	AUX. ELECTRODE VOLUME SQ. INCH X INCH	AUX. ELECTRODE ASSIGNED CODE	REMARKS
1	-	Pre-Contract	1	Nylon	P2505W	17	18	None			
2	-	Pre-Contract	13	Nylon	P2505W	17	18	None			
3	1	Baseline	14	Nylon	P2505W	17	18	Std.	1.6 x .025"		
4	1	Baseline	15	Nylon	P2505W	17	18	Std.	1.6 x .025"		
5	1	Thin Plate	16	Nylon	P2505W	19	20	Std.	1.6 x .025"		
6	1	Thin Plate	17	Nylon	P2505W	19	20	Std.	1.6 x .025"		
7	1	Opposed Terminals	22	Nylon	P2505W	17	18	Std.	1.6 x .025"		
8	1	Opposed Terminals	23	Nylon	P2505W	17	18	Std.	1.6 x .025"		
9	2	Baseline (WEX)	24	Polyprop	WEX1242W	17	18	Std.	1.6 x .025"		
10	2	Baseline (WEX)	25	Polyprop	WEX1242W	17	18	Std.	1.6 x .025"		
11	2	Baseline (Shimmed)	26	Nylon	P2505W	17	18	Std.	1.6 x .025"		Shim Thick. = .030"
12	2	Baseline (Shimmed)	27	Nylon	P2505W	17	18	Std.	1.6 x .025"		Shim Thick. = .030"
13	2	Baseline (Ft & W. Poly P.)	28	Polyprop	Ft2140W + Woven	17	18	Std.	1.6 x .025"		
14	2	Baseline (Ft & W. Poly P.)	29	Polyprop	Ft2140W + Woven	17	18	Std.	1.6 x .025"		
15	3	Thin Plate	32	Nylon	P2505W	19	20	Std.	1.6 x .025"	Wrap 1	
16	3	Thin Plate	33	Nylon	P2505W	19	20	Std.	1.6 x .025"	Wrap 1	*
17	3	Thin Plate	34	Nylon	P2505W	19	20	Std.	1.6 x .025"	Wrap 2	*
18	3	Thin Plate	35	Nylon	P2505W	19	20	Std.	1.6 x .025"	Wrap 2	
19	3	Thin Plate	36	Nylon	P2505W	19	20	Std.	1.6 x .025"		Aux. Elect. Isolated From Can *
20	3	Thin Plate	37	Nylon	P2505W	19	20	Std.	1.6 x .025"	Wrap 2	Aux. Elect. Isolated From Can *
21	3	Thin Plate (MF)	38	Polyprop	Hercules MF	19	20	Std.	1.6 x .025"	Wrap 2	
22	3	Thin Plate (MF)	39	Polyprop	Hercules MF	19	20	Std.	1.6 x .025"	Wrap 2	*
23	3	Thin Plate (Tight)	40	Nylon	P2505W	20	21	Std.	1.6 x .025"	Wrap 2	*
24	3	Thin Plate (Tight)	41	Nylon	P2505W	20	21	Std.	1.6 x .015"	Wrap 2	
25	3	Thin Plate (T)	42	Polyprop	T21047W	19	20	Std.	1.6 x .025"	Wrap 2	
26	3	Thin Plate (T)	43	Polyprop	T21047W	19	20	Std.	1.6 x .025"	Wrap 2	*
27	3	Baseline	44	Nylon	P2505W	17	18	Std.	1.6 x .025"	Wrap 2	*
28	3	Baseline	45	Nylon	P2505W	17	18	Std.	1.6 x .025"	Wrap 2	

APPENDIX N-1

TABULATION OF
CELL DESIGN DESCRIPTION

ITEM NO.	DESIGN GROUP	CELL DESIGN DESCRIPTION	CELL S/N	SEPARATOR TYPE	SEPARATOR NO.	ELECTRODE NO. (+)	ELECTRODE NO. (-)	AUX. ELECTRODE DESIGN	AUX. ELECTRODE VOLUME SQ. INCH X INCH	AUX. ELECTRODE ASSIGNED CODE	REMARKS
29	Parametric	Thin Plate	47	Nylon	P2505W	19	20	GAC Supplied	1.6 x .010"	I	
30	Parametric	Thin Plate	48	Nylon	P2505W	19	20	Sint. Tef.	" x .010"	II	
31	Parametric	Thin Plate	49	Nylon	P2505W	19	20	Sint. Tef.	" x .010"	II	
32	Parametric	Thin Plate	51	Nylon	P2505W	19	20	Std.	x .025"	III	
33	Parametric	Thin Plate	52	Nylon	P2505W	19	20	2 Sides Tef.	x .025"	IV	
34	Parametric	Thin Plate	53	Nylon	P2505W	19	20	2 Sides Tef.	x .025"	IV	
35	Parametric	Thin Plate	54	Nylon	P2505W	19	20	Film & Tef. Disb.	x .025"	V	
36	Parametric	Thin Plate	55	Nylon	P2505W	19	20	Large	2(4.1 x .025")	VI	
37	Parametric	Thin Plate	56	Nylon	P2505W	19	20	Film & Tef. Disb.	1.6 x .025"	V	
38	Parametric	Thin Plate (WEX)	57	Polyprop	WEX1242W	19	20	GAC Supplied	1.6 x .010"	I	
39	Parametric	Thin Plate (WEX)	58	Polyprop	WEX1242W	19	20	Sint. Tef.	1.6 x .010"	II	
40	Parametric	Thin Plate (WEX)	59	Polyprop	WEX1242W	19	20	Sint. Tef.	1.6 x .010"	II	
41	Parametric	Thin Plate (WEX)	60	Polyprop	WEX1242W	19	20	Std.	1.6 x .025"	III	
42	Parametric	Thin Plate (WEX)	61	Polyprop	WEX1242W	19	20	Std.	1.6 x .025"	III	
43	Parametric	Thin Plate (WEX)	62	Polyprop	WEX1242W	19	20	2 Sides Tef.	1.6 x .025"	IV	
44	Parametric	Thin Plate (WEX)	64	Polyprop	WEX1242W	19	20	Film & Tef. Disb.	1.6 x .025"	VI	
45	Parametric	Thin Plate (WEX)	65	Polyprop	WEX1242W	19	20	Large	2(4.1 x .025")	VI	One Aux. on Each Narrow Face
46	Parametric	Baseline	67	Nylon	P2505W	17	18	GAC Supplied	1.6 x .010"	I	
47	Parametric	Baseline	68	Nylon	P2505W	17	18	Sint. Tef.	1.6 x .010"	II	
48	Parametric	Baseline	69	Nylon	P2505W	17	18	Sint. Tef.	1.6 x .010"	II	
49	Parametric	Baseline	72	Nylon	P2505W	17	18	Std.	1.6 x .025"	III	
50	Parametric	Baseline	73	Nylon	P2505W	17	18	2 Sides Tef.	1.6 x .025"	IV	
51	Parametric	Baseline	74	Nylon	P2505W	17	18	2 Sides Tef.	1.6 x .025"	IV	
52	Parametric	Baseline	75	Nylon	P2505W	17	18	Film & Tef. Disb.	1.6 x .025"	V	
53	Parametric	Baseline	76	Nylon	P2505W	17	18	Large	2(4.1 x .025")	VI	One Aux. on Each Narrow Face
54	Life	Baseline	77	Polyprop	WEX1242W	17	18	None			
55	Life	Baseline	78	Polyprop	WEX1242W	17	18	None			
56	Life	Baseline	79	Polyprop	WEX1242W	17	18	None			
57	Life	Baseline	80	Polyprop	WEX1242W	17	18	None			
58	Life	Baseline	81	Polyprop	WEX1242W	17	18	None			
59	Life	Baseline	82	Polyprop	WEX1242W	17	18	None			

APPENDIX N-1

TABULATION OF
CELL DESIGN DESCRIPTION

ITEM NO.	DESIGN GROUP	CELL DESIGN DESCRIPTION	CELL S/N	SEPARATOR TYPE	SEPARATOR NO.	ELECTRODE NO. (+)	ELECTRODE NO. (-)	AUX. ELECTRODE DESIGN	AUX. ELECTRODE VOLUME SQ. INCH X INCH	AUX. ELECTRODE ASSIGNED CODE	REMARKS
60	Life	Thin Plate	83	Nylon	P2505W	19	20	None			
61	Life	Thin Plate	84	Nylon	P2505W	19	20	None			
62	Life	Thin Plate	85	Nylon	P2505W	19	20	None			
63	Life	Thin Plate	86	Nylon	P2505W	19	20	None			
64	Life	Thin Plate	87	Nylon	P2505W	19	20	None			
65	Life	Thin Plate	88	Nylon	P2505W	19	20	None			
66	Life	Thin Plate	89	Nylon	P2505W	19	20	None			
67	Life	Thin Plate	90	Nylon	P2505W	19	20	None			
68	Life	Thin Plate	91	Nylon	P2505W	19	20	None			
69	Life	Thin Plate	92	Nylon	P2505W	19	20	None			
70	Life	Thin Plate	93	Nylon	P2505W	19	20	None			
71	Life	Thin Plate	94	Nylon	P2505W	19	20	None			
72	Life	Thin Plate	95	Nylon	P2505W	19	20	None			
73	Life	Thin Plate	96	Nylon	P2505W	19	20	None			
74	Life	Thin Plate	97	Nylon	P2505W	19	20	None			
75	Life	Thin Plate	98	Nylon	P2505W	19	20	None			
76	Life	Thin Plate	99	Nylon	P2505W	19	20	None			
77	Life	Thin Plate	100	Nylon	P2505W	19	20	None			
78	Life	Thin Plate	101	Nylon	P2505W	19	20	None			
79	Life	Thin Plate	102	Nylon	P2505W	19	20	None			
80	Life	Thin Plate	103	Nylon	P2505W	19	20	None			
81	Life	Thin Plate	104	Nylon	P2505W	19	20	None			
82	Life	Thin Plate	105	Nylon	P2505W	19	20	None			
83	Life	Thin Plate	106	Nylon	P2505W	19	20	None			
84	Life	Thin Plate	107	Nylon	P2505W	19	20	None			
85	Life	Thin Plate	108	Nylon	P2505W	19	20	None			
86	Life	Thin Plate	109	Nylon	P2505W	19	20	None			
87	Life	Thin Plate	110	Nylon	P2505W	19	20	None			
88	Life	Thin Plate	111	Nylon	P2505W	19	20	None			
89	Life	Thin Plate	112	Nylon	P2505W	19	20	None			

APPENDIX N-1

TABULATION OF
CELL DESIGN DESCRIPTION

ITEM NO.	DESIGN GROUP	CELL DESIGN DESCRIPTION	CELL S/N	SEPARATOR TYPE	SEPARATOR NO.	ELECTRODE NO. (+)	ELECTRODE NO. (-)	AUX. ELECTRODE DESIGN	AUX. ELECTRODE VOLUME SQ. INCH X INCH	AUX. ELECTRODE ASSIGNED CODE	REMARKS
90	Life	Thin Plate	113	Nylon	P2505W	19	20	None			
91	Life	Thin Plate	114	Nylon	P2505W	19	20	None			
92	Life	Thin Plate	115	Nylon	P2505W	19	20	None			
93	Life	Thin Plate	116	Nylon	P2505W	19	20	None			
94	Life	Thin Plate	117	Nylon	P2505W	19	20	None			
95	Life	Thin Plate	118	Nylon	P2505W	19	20	None			
96	Life	Thin Plate	119	Nylon	P2505W	19	20	None			
97	Life	Thin Plate	120	Nylon	P2505W	19	20	None			
98	Life	Thin Plate	121	Nylon	P2505W	19	20	None			
99	Life	Thin Plate	122	Nylon	P2505W	19	20	None			
100	Life	Thin Plate	123	Nylon	P2505W	19	20	None			
101	Life	Thin Plate	124	Nylon	P2505W	19	20	None			
102	Life	Thin Plate	125	Poly Prop	WEX1242W	19	20	None			
103	Life	Thin Plate	126	Poly Prop	WEX1242W	19	20	None			
104	Life	Thin Plate	127	Poly Prop	WEX1242W	19	20	None			
105	Life	Thin Plate	128	Poly Prop	WEX1242W	19	20	None			
106	Life	Thin Plate	129	Poly Prop	WEX1242W	19	20	None			
107	Life	Thin Plate	130	Poly Prop	WEX1242W	19	20	None			

NOTES: *Hold Down (E.P. P/N 09-04-006-3) was removed from these and all cells for parametric and life test groups.

APPENDIX N-2

TABULATION OF CELLS' PHYSICAL DATA

CELL S/N	DESIGN GROUP	DESIGN DESCRIPTION	POSITIVE ELECTRODE DATA GROUP WT-G.	TAB WT-G.	CALC. ACT. MAT -G.	NEGATIVE ELECTRODE DATA GROUP WT-G.	TAB WT-G.	CALC. ACT. MAT -G.	CORE WT-G.	CORE THICK. -INCH	CELL DRY(*) WT-G.	CELL WET WT-G. W/O GAUGE	W/GAUGE	ELECTROLYTE AMOUNT CC	% RATIO (**)
1	-	Pre-Contr.	1095	33	500	1251	35	589	2346	-	-	3954	-	414	23
13	-	Pre-Contr.	1083	33	495	1268	35	589	2351	-	-	3959	-	414	23
14	1	B.L.	1023	47.5	438	1362	49	656	2425	1.340	3497	4006	4347	390	21
15	1	B.L.	1022	47.5	438	1362	49	656	2425	1.335	3494	4007	4346	390	21
16	1	Thin Pl.	1052	51	460	1310	54	612	2410	1.350	3474	3985	4335	387	21
17	1	Thin Pl.	1052	51	460	1310	54	612	2409	1.365	3480	3986	4337	386	21
22	1	Opposed Term.	1189	119	438	1339	126	550	2540	1.345	3786	4324	4673	410	21
23	1	Opposed Term.	1187	119	438	1339	126	550	2542	1.350	3790	4326	4679	410	21
24	2	B.L. - WEX	1042	47.5	448	1282	49	594	2389	1.270	3808	-	4261	350	19
25	2	B.L. - WEX	1042	47.5	448	1283	49	594	2392	1.267	3810	-	4262	350	19
26	2	B.L. + Shims	1040	47.5	448	1281	49	594	2376	1.425	4099	-	4547	346	19
27	2	B.L. + Shims	1041	47.5	448	1282	49	594	2373	1.410	4099	-	4545	346	19
28	2	B.L. FT & W	1040	47.5	448	1282	49	594	2427	1.290	3848	-	4309	354	19
29	2	B.L. FT & W	1040	47.5	448	1281	49	594	2429	1.300	3846	-	4305	354	19
32	3	Thin Pl.	1087	51	495	1288	54	704	2439	1.335	3504	3879	4363	375	20
33	3	Thin Pl.	1090	51	495	1288	54	704	2441	1.337	3495	3862	4348	375	20
34	3	Thin Pl.	1090	51	495	1290	54	704	2442	1.341	3492	3864	4352	375	20
35	3	Thin Pl.	1092	51	495	1288	54	704	2437	1.331	3496	3864	4352	375	20
36	3	Thin Pl.	1089	51	495	1287	54	704	2432	1.340	3488	3856	4344	375	20
37	3	Thin Pl.	1090	51	495	1289	54	704	2436	1.343	3499	3869	4356	375	20
38	3	Thin Pl. - MF	1091	51	495	1290	54	704	2430	1.339	3373	3969	4339	374	20
39	3	Thin Pl. - MF	1089	51	495	1288	54	704	2434	1.333	3374	3970	4340	374	20
40	3	Thin Pl.-Tight	1148	51	525	1355	54	739	2563	1.351	3619	3988	4503	394	20
41	3	Thin Pl.-Tight	1143	51	525	1355	54	739	2561	1.350	3623	3990	4504	394	20
42	3	Thin Pl. - T	1148	51	525	1354	54	739	2564	1.348	3629	3990	4506	394	20
43	3	Thin Pl. - T	1147	51	525	1357	54	739	2566	1.352	3619	3981	4499	394	20
44	3	B.L.	1179	47.5	538	1417	49	712	2651	1.374	3698	4061	4596	408	20
45	3	B.L.	1180	47.5	538	1434	49	712	2661	1.365	3724	4090	4625	408	20
47	Parametric	Thin Pl.	1038	51	460	1318	54	642	2432	1.297	3482	3984	4472	385	20.5
48	Parametric	Thin Pl.	1038	51	460	1315	54	642	2426	1.296	3475	3976	4464	385	20.5
49	Parametric	Thin Pl.	1038	51	460	1315	54	642	2428	1.305	3486	3988	4476	385	20.5

APPENDIX N-2

TABULATION OF CELLS' PHYSICAL DATA

CELL S/N	DESIGN GROUP	DESIGN DESCRIPTION	POSITIVE ELECTRODE DATA GROUP WT-G.	TAB WT-G.	CALC. ACT. MAT -G.	NEGATIVE ELECTRODE DATA GROUP WT-G.	TAB WT-G.	CALC. ACT. MAT -G.	CORE WT-G.	CORE THICK. -INCH	CELL DRY(*) WT-G.	CELL WET WT-G. W/O GAUGE	CELL WET WT-G. W/GAUGE	ELECTROLYTE AMOUNT CC	ELECTROLYTE % RATIO (**)
51	Parametric	Thin Pl.	1040	51	460	1315	54	642	2432	1.322	3461	3964	4452	385	20.5
52	Parametric	Thin Pl.	1037	51	460	1316	54	642	2432	1.345	3470	3972	4460	385	20.5
53	Parametric	Thin Pl.	1031	51	460	1316	54	642	2423	1.322	3467	3969	4457	385	20.5
54	Parametric	Thin Pl.	1032	51	460	1317	54	642	2423	1.330	3475	3977	4465	385	20.5
55	Parametric	Thin Pl.	1033	51	460	1317	54	642	2429	1.330	3489	3991	4479	385	20.5
56	Parametric	Thin Pl.	1036	51	460	1317	54	642	2430	1.327	3481	3983	4471	385	20.5
57	Parametric	Thin Pl. (WEX)	1038	51	460	1317	54	642	2453	1.318	3506	3959	4447	385	20.5
58	Parametric	Thin Pl. (WEX)	1038	51	460	1320	54	642	2450	1.325	3504	3959	4447	385	20.5
59	Parametric	Thin Pl. (WEX)	1038	51	460	1320	54	642	2450	1.319	3495	3949	4437	385	20.5
60	Parametric	Thin Pl. (WEX)	1036	51	460	1320	54	642	2448	1.317	3485	3937	4425	385	20.5
61	Parametric	Thin Pl. (WEX)	1036	51	460	1321	54	642	2454	1.316	3497	3949	4437	385	20.5
62	Parametric	Thin Pl. (WEX)	1036	51	460	1323	54	642	2450	1.322	3505	3958	4448	385	20.5
64	Parametric	Thin Pl. (WEX)	1037	51	460	1323	54	642	2457	1.343	3510	3963	4453	385	20.5
65	Parametric	Thin Pl. (WEX)	1037	51	460	1323	54	642	2455	1.332	3517	3970	4460	385	20.5
67	Parametric	B.L.	1099	47.5	505	1367	49	710	2535	1.385	3586	4089	4577	385	20
68	Parametric	B.L.	1096	47.5	505	1367	49	710	2528	1.374	3574	4075	4563	385	20
69	Parametric	B.L.	1096	47.5	505	1367	49	710	2526	1.375	3565	4067	4555	385	20
72	Parametric	B.L.	1096	47.5	505	1368	49	710	2532	1.390	3592	4093	4581	385	20
73	Parametric	B.L.	1098	47.5	505	1368	49	710	2530	1.371	3574	4075	4563	385	20
74	Parametric	B.L.	1095	47.5	505	1369	49	710	2525	1.360	3582	4084	4572	385	20
75	Parametric	B.L.	1096	47.5	505	1369	49	710	2526	1.374	3582	4083	4571	385	20
76	Parametric	B.L.	1098	47.5	505	1369	49	710	2530	1.352	3599	4101	4589	385	20
77	Life	Baseline	1073	47.5	495	1338	49	697	2471	1.413	3437	3937	4425	385	20
78	Life	Baseline	1073	47.5	495	1338	49	697	2471	1.409	3429	3928	4416	385	20
79	Life	Baseline	1073	47.5	495	1338	49	697	2470	1.410	3437	3936	4424	385	20
80	Life	Baseline	1073	47.5	495	1336	49	697	2472	1.405	3417	3917	4405	385	20
81	Life	Baseline	1073	47.5	495	1338	49	697	2475	1.415	3446	3935	4423	385	20
82	Life	Baseline	1073	47.5	495	1338	49	697	2477	1.425	3423	3922	4410	385	20
83	Life	Thin Plate	1054	51	469	1251	54	629	2382	1.410	3435	3936		385	21
84	Life	Thin Plate	1053	51	469	1251	54	629	2378	1.412	3441	3941		385	21
85	Life	Thin Plate	1053	51	469	1252	54	629	2374	1.410	3437	3937		385	21

APPENDIX N-2

TABULATION OF CELLS' PHYSICAL DATA

CELL S/N	DESIGN GROUP	DESIGN DESCRIPTION	POSITIVE ELECTRODE DATA			NEGATIVE ELECTRODE DATA			CORE	CORE	CELL	CELL WET WT-G.		ELECTROLYTE	
			GROUP WT-G.	TAB WT-G.	CALC. ACT. MAT -G.	GROUP WT-G.	TAB WT-G.	CALC. ACT. MAT -G.	WT-G.	THICK. -INCH	DRY(*) WT-G.	W/O GAUGE	W/GAUGE	AMOUNT CC	% RATIO (**)
86	Life	Thin Plate	1053	51	469	1252	54	629	2374	1.404	3424	3924		385	21
87	Life	Thin Plate	1054	51	469	1251	54	629	2370	1.402	3424	3921		385	21
88	Life	Thin Plate	1054	51	469	1251	54	629	2372	1.404	3440	3940		385	21
89	Life	Thin Plate	1053	51	469	1252	54	629	2370	1.403	3439	3939		385	21
90	Life	Thin Plate	1053	51	469	1251	54	629	2374	1.409	3434	3932		385	21
91	Life	Thin Plate	1053	51	469	1251	54	629	2369	1.405	3413	3912		385	21
92	Life	Thin Plate	1054	51	469	1251	54	629	2376	1.405	3418	3917		385	21
93	Life	Thin Plate	1063	51	469	1244	54	629	2352	1.403	3417	3916		385	21
94	Life	Thin Plate	1063	51	469	1245	54	629	2352	1.411	3419	3914		385	21
95	Life	Thin Plate	1064	51	469	1244	54	629	2353	1.402	3410	3910		385	21
96	Life	Thin Plate	1064	51	469	1244	54	629	2350	1.404	3403	3902		385	21
97	Life	Thin Plate	1063	51	469	1245	54	629	2349	1.409	3413	3913		385	21
98	Life	Thin Plate	1063	51	469	1245	54	629	2352	1.410	3422	3921		385	21
99	Life	Thin Plate	1063	51	469	1245	54	629	2352	1.402	3419	3920		385	21
100	Life	Thin Plate	1063	51	469	1247	54	629	2363	1.403	3426	3925		385	21
101	Life	Thin Plate	1063	51	469	1245	54	629	2349	1.405	3411	3909		385	21
102	Life	Thin Plate	1063	51	469	1245	54	629	2350	1.402	3399	3899		385	21
103	Life	Thin Plate	1065	51	469	1257	54	629	2398	1.400	3465	3964		385	21
104	Life	Thin Plate	1065	51	469	1257	54	629	2396	1.401	3460	3959		385	21
105	Life	Thin Plate	1065	51	469	1257	54	629	2395	1.400	3459	3963		385	21
106	Life	Thin Plate	1065	51	469	1257	54	629	2396	1.398	3455	3953		385	21
107	Life	Thin Plate	1065	51	469	1257	54	629	2393	1.399	3457	3955		385	21
108	Life	Thin Plate	1065	51	469	1256	54	629	2395	1.400	3447	3945		385	21
109	Life	Thin Plate	1065	51	469	1256	54	629	2392	1.401	3452	3951		385	21
110	Life	Thin Plate	1065	51	469	1257	54	629	2397	1.399	3453	3954		385	21
111	Life	Thin Plate	1065	51	469	1257	54	629	2395	1.403	3456	3955		385	21
112	Life	Thin Plate	1065	51	469	1257	54	629	2390	1.398	3460	3958		385	21
113	Life	Thin Plate	1057	51	469	1241	54	629	2336	1.409	3392	3888		385	21
114	Life	Thin Plate	1057	51	469	1241	54	629	2337	1.405	3396	3893		385	21
115	Life	Thin Plate	1057	51	469	1242	54	629	2342	1.410	3415	3917		385	21
116	Life	Thin Plate	1057	51	469	1241	54	629	2340	1.411	3412	3909		385	21

APPENDIX N-2

TABULATION OF CELLS' PHYSICAL DATA

CELL S/N	DESIGN GROUP	DESIGN DESCRIPTION	POSITIVE ELECTRODE DATA			NEGATIVE ELECTRODE DATA			CORE	CORE THICK.	CELL DRY(*)	CELL WET WT-G.		ELECTROLYTE	
			GROUP WT-G.	TAB WT-G.	CALC. ACT. MAT -G.	GROUP WT-G.	TAB WT-G.	CALC. ACT. MAT -G.	WT-G.	-INCH	WT-G.	W/O GAUGE	W/GAUGE	AMOUNT CC	% RATIO (**)
117	Life	Thin Plate	1057	51	469	1241	54	629	2334	1.401	3391	3890		385	21
118	Life	Thin Plate	1057	51	469	1242	54	629	2340	1.400	3397	3897		385	21
119	Life	Thin Plate	1057	51	469	1241	54	629	2336	1.399	3409	3909		385	21
120	Life	Thin Plate	1057	51	469	1241	54	629	2337	1.398	3387	3884		385	21
121	Life	Thin Plate	1057	51	469	1242	54	629	2338	1.402	3403	3902		385	21
122	Life	Thin Plate	1057	51	469	1242	54	629	2336	1.399	3404	3904		385	21
123	Life	Thin Plate	1054	51	469	1239	54	629	2334	1.399	3420	3920		385	21
124	Life	Thin Plate	1054	51	469	1239	54	629	2331	1.405	3418	3917		385	21
125	Life	Thin Plate	1054	51	469	1239	54	629	2387	1.351	3456	3955		385	21
126	Life	Thin Plate	1054	51	469	1239	54	629	2384	1.350	3451	3951		385	21
127	Life	Thin Plate	1055	51	469	1239	54	629	2388	1.335	3467	3966		385	21
128	Life	Thin Plate	1055	51	469	1239	54	629	2389	1.341	3448	3947		385	21
129	Life	Thin Plate	1055	51	469	1239	54	629	2387	1.331	3436	3935		385	21
130	Life	Thin Plate	1054	51	469	1239	54	629	2385	1.335	3451	3949		385	21

NOTES: (*) Cell Case Wt. for all Group 1 & 2 Cells, except Opposite terminal Cells = 880G.
Cell Case Wt. for Opposite terminal Cells = 1010G.
Cell Case Wt. for all Group 3, Parametric & Life Cells = 510G.
The Cover Weight for all Group 1 & 2 Cells, except Opposite terminal Cells = 190G.
The cover Weight for all Opposite terminal Cells = 239G.
The Cover Weight for all Group 3 Cells = 175G.
The Cover Weight for all Parametric Cells = 180G.
The Cover Weight for all Life Cells - 171G.
All Case & Cover Material for Groups 1 & 2 were 0.051" stock.
All subsequent cells used 0.031" stock.

(**) % Electrolyte Ratio = Electrolyte in grams ÷ core weight in grams x 100.

APPENDIX N-3

TABULATION OF
ADDITIONAL CELL PRODUCTION DATA

CELL S/N	DESIGN GROUP	SEPARATOR			ELECTROLYTE			ELECTRODES				TERMINALS			REMARKS
		TYPE	LOT#	ANALYSIS REPORT	LOT#	ANALYSIS REPORT	FILLING DATE	(+) LOT#	(-) LOT#	(+) THICK.	(-) THICK.	DESIGN DESCRIPT.	DWG#	LOT#	
1	-	P2505W										Platform			
13	-	P2505W										Platform			
14	1	P2505W	#1		68		1-10-71	6	3	.028	.028	Platform			
15	1	P2505W	#1		68		1-10-71	6	3	.028	.028	Platform			
16	1	P2505W	#1		68		1-10-71	2	1	.022	.022	Platform			
17	1	P2505W	#1		68		1-10-71	2	1	.022	.022	Platform			
22	1	P2505W	#1		68		1-10-71	6	3	.028	.028	Platform			
23	1	P2505W	#1		68		1-10-71	6	3	.028	.028	Platform			
24	2	WEX1242W	#1		#1		5-25-71	7	4	.028	.027	Platform			
25	2	WEX1242W	#1		#1		5-25-71	7	4	.028	.027	Platform			
26	2	P2505W	#4		#1		5-25-71	7	4	.028	.027	Platform			
27	2	P2505W	#4		#1		5-25-71	7	4	.028	.027	Platform			
28	2	FT2140 + Woven	#1		#1		5-25-71	7	4	.028	.027	Platform			
29	2	FT2140 + Woven	#1		#1		5-25-71	7	4	.028	.027	Platform			
32	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
33	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
34	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
35	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
36	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
37	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
38	3	Hercules MF	#1		46		11-18-71	3,5 & 6	5	.021	.023	Platform			
39	3	Hercules MF	#1		46		11-18-71	3,5 & 6	5	.021	.023	Platform			
40	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
41	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
42	3	T 21047W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
43	3	T 21047W	#1		46		11-18-71	3,5 & 6	4	.021	.024	Platform			
44	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.028	.028	Platform			
45	3	P2505W	#1		46		11-18-71	3,5 & 6	4	.028	.028	Platform			
47	Parametric	P2505W	#2		49		9-05-72	8,9,10 & 11	7,8,9,10,11	.021	.024	LUG			
48	Parametric	P2505W	#2		49		9-05-72	8,9,10 & 11	7,8,9,10,11	.021	.024	LUG			
49	Parametric	P2505W	#2		49		9-05-72	8,9,10 & 11	7,8,9,10,11	.021	.024	LUG			
51	Parametric	P2505W	#2		49		9-05-72	8,9,10 & 11	7,8,9,10,11	.021	.024	LUG			

APPENDIX N-3

TABULATION OF
ADDITIONAL CELL PRODUCTION DATA

CELL S/N	DESIGN GROUP	SEPARATOR			ELECTROLYTE			ELECTRODES				TERMINALS			REMARKS
		TYPE	LOT#	ANALYSIS REPORT	LOT#	ANALYSIS REPORT	FILLING DATE	(+) LOT#	(-) LOT#	(+) THICK.	(-) THICK.	DESIGN DESCRIPT.	DWG#	LOT#	
52	Parametric	P2505W	#2		49		9-05-72	8,9,10 & 11	7,8,9,10,11	.021	.024	LUG			
53	Parametric	P2505W	#2		49		9-05-72	8,9,10 & 11	7,8,9,10,11	.021	.024	LUG			
54	Parametric	P2505W	#2		49		9-05-72	8,9,10 & 11	7,8,9,10,11	.021	.024	LUG			
55	Parametric	P2505W	#2		49		9-05-72	8,9,10 & 11	7,8,9,10,11	.021	.024	LUG			
56	Parametric	P2505W	#2		49		9-05-72	8,9,10 & 11	7,8,9,10,11	.021	.024	LUG			
57	Parametric	WEX1242W	#2		49		9-25-72	12 & 13	7,8,9,10,11	.021	.024	LUG			
58	Parametric	WEX1242W	#2		49		9-25-72	12 & 13	7,8,9,10,11	.021	.024	LUG			
59	Parametric	WEX1242W	#2		49		9-25-72	12 & 13	7,8,9,10,11	.021	.024	LUG			
60	Parametric	WEX1242W	#2		49		9-25-72	12 & 13	7,8,9,10,11	.021	.024	LUG			
61	Parametric	WEX1242W	#2		49		9-25-72	12 & 13	7,8,9,10,11	.021	.024	LUG			
62	Parametric	WEX1242W	#2		49		9-25-72	12 & 13	7,8,9,10,11	.021	.024	LUG			
63	Parametric	WEX1242W	#2		49		9-25-72	12 & 13	7,8,9,10,11	.021	.024	LUG			
64	Parametric	WEX1242W	#2		49		9-25-72	12 & 13	7,8,9,10,11	.021	.024	LUG			
65	Parametric	WEX1242W	#2		49		9-25-72	12 & 13	7,8,9,10,11	.021	.024	LUG			
67	Parametric	P2505W	#1		49		9-26-72	10 & 11	6,8,9,10,7	.024	.029	LUG			
68	Parametric	P2505W	#1		49		9-26-72	10 & 11	6,8,9,10,7	.024	.029	LUG			
69	Parametric	P2505W	#1		49		9-26-72	10 & 11	6,8,9,10,7	.024	.029	LUG			
72	Parametric	P2505W	#1		49		9-26-72	10 & 11	6,8,9,10,7	.024	.029	LUG			
73	Parametric	P2505W	#1		49		9-26-72	10 & 11	6,8,9,10,7	.024	.029	LUG			
74	Parametric	P2505W	#1		49		9-26-72	10 & 11	6,8,9,10,7	.024	.029	LUG			
75	Parametric	P2505W	#1		49		9-26-72	10 & 11	6,8,9,10,7	.024	.029	LUG			
76	Parametric	P2505W	#1		49		9-26-72	10 & 11	6,8,9,10,7	.024	.029	LUG			
77	Life	WEX1242	#1		132		6-22-73	10,11 & 12	10 & 11	.024	.027	LUG-BUTT			
78	Life	WEX1242	#1		132		6-22-73	10,11 & 12	10 & 11	.024	.027	LUG-BUTT			
79	Life	WEX1242	#1		132		6-22-73	10,11 & 12	10 & 11	.024	.027	LUG-BUTT			
80	Life	WEX1242	#1		132		6-22-73	10,11 & 12	10 & 11	.024	.027	LUG-BUTT			
81	Life	WEX1242	#1		132		6-22-73	10,11 & 12	10 & 11	.024	.027	LUG-BUTT			
82	Life	WEX1242	#1		132		6-22-73	10,11 & 12	10 & 11	.024	.027	LUG-BUTT			
83	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			
84	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			
85	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			
86	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			

APPENDIX N-3

TABULATION OF
ADDITIONAL CELL PRODUCTION DATA

CELL S/N	DESIGN GROUP	SEPARATOR TYPE	SEPARATOR LOT#	SEPARATOR ANALYSIS REPORT	ELECTROLYTE LOT#	ELECTROLYTE ANALYSIS REPORT	ELECTROLYTE FILLING DATE	ELECTRODES (+) LOT#	ELECTRODES (-) LOT#	ELECTRODES (+) THICK.	ELECTRODES (-) THICK.	TERMINALS DESIGN DESCRIPT.	TERMINALS DWG#	TERMINALS LOT#	REMARKS
87	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			
88	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			
89	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			
90	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			
91	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			
92	Life	P2505W	#2		132		6-22-73	15 & 17	15	.021	.023	LUG-BUTT			
93	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
94	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
95	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
96	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
97	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
98	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
99	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
100	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
101	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
102	Life	P2505W	#1		132		6-22-73	15	12,15 & 16	.021	.023	LUG-BUTT			
103	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
104	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
105	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
106	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
107	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
108	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
109	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
110	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
111	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
112	Life	P2505W	#1		132		6-22-73	15 & 16	13	.021	.023	LUG-BUTT			
113	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
114	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
115	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
116	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
117	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
118	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			

APPENDIX N-3

TABULATION OF
ADDITIONAL CELL PRODUCTION DATA

CELL S/N	DESIGN GROUP	SEPARATOR			ELECTROLYTE			ELECTRODES				TERMINALS			REMARKS
		TYPE	LOT#	ANALYSIS REPORT	LOT#	ANALYSIS REPORT	FILLING DATE	(+) LOT#	(-) LOT#	(+) THICK.	(-) THICK.	DESIGN DESCRIPT.	DWG#	LOT#	
119	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
120	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
121	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
122	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
123	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
124	Life	P2505W	#4		132		6-22-73	16	13	.021	.023	LUG-BUTT			
125	Life	WEX1242W	#1		132		6-22-73	16	13	.021	.023	LUG-BUTT			
126	Life	WEX1242W	#1		132		6-22-73	16	13	.021	.023	LUG-BUTT			
127	Life	WEX1242W	#1		132		6-22-73	16	13	.021	.023	LUG-BUTT			
128	Life	WEX1242W	#1		132		6-22-73	16	13	.021	.023	LUG-BUTT			
129	Life	WEX1242W	#1		132		6-22-73	16	13	.021	.023	LUG-BUTT			
130	Life	WEX1242W	#1		132		6-22-73	16	13	.021	.023	LUG-BUTT			

NOTES: (A) Suppliers

Supplier	Material:
1. P2505 Supplier: Pellon Corp.	Nylon 2505
2. WEX1242 Supplier: GAF Corp.	Polypropylene
3. FT 2140 Supplier: Pellon Corp.	Polypropylene
4. Woven Supplier: Howard Textile Mills	Polypropylene
5. Hercules MF Supplier: Hercules	Polypropylene
6. T 21047 Supplier: Kendall Mills	Polypropylene

W = Material was washed in 3* Methanol + Dist. Water Washings

(B) Electrolyte Supplier: McKesson Chemical

(C) Terminal Supplier: Ceramaseal Corp.

(D) Electrode Supplier: Eagle-Picher, Colorado Springs
Semi Automatic Process Applied from Design Group 3.

APPENDIX O

DVTP 153-2
TEST PLAN - PART II
THERMAL TEST PLAN

REVISION A

CONTRACT NO. 0-15161
ITEM 2.0 DOCUMENTATION
SUBITEM 5.2

19 MARCH 1971

FOR

GRUMMAN AEROSPACE CORPORATION
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1.0 SCOPE

This document describes in detail the nature and sequence of the calorimetric testing to be performed on 100 ampere-hour sealed nickel-cadmium cells. The objective of this Development Test is to establish the heat generation characteristics of the cell under test as a function of actual orbital operational conditions. These tests are to be performed as part of the 100 ampere-hour Cell Development Program, GAC Purchase Order 0-15161 and Prime Contract No. NAS9-11074. Tests outlined in this document shall be performed on two (2) cells (one thin electrode type and one opposite-end terminal type, S/N 16 and 22) which have completed testing in accordance with Eagle-Picher DVTP 153-1, Part I. Data from the tests described herein will be considered in establishing the final design for additional cells to be manufactured for GAC for parametric testing.

1.1 Calorimeter Design and Theory of Operation

The test objectives, procedures, and details of the calorimeter's design have been the object of many discussions between Grumman Aerospace Corporation and Eagle Picher. The objectives of the test effort can be listed in order of decreasing importance as follows:

(a) determine the average orbital heat generation rate at 20°C, 50%, 30%, 12% DOD, modified voltage limit charge,

(b) determine the average heat generation rates on charge and on discharge (separately) for the above conditions,

(c)
(d) same as above at 0°C,

(e) determine the variation of heat generation rate with state of charge.

The calorimeter design described below has the potential to meet the objectives stated above. In this design, the heat generated within the cell is transferred through the four vertical faces of the cell (header and bottom are insulated), across a kapton film and silicone grease interface to copper cold plates (Figure 2). The cold plates will be held in place by aluminum restraining braces (Figure 3). The entire fixture will then be insulated with expanded polyurethane foam and aluminum foil, and guard heaters attached to the leads to minimize all heat transfer with the test environment (figure 4). In this manner, all the heat rejected by the cell will be picked up by the fluid in the cold plates and detected as the temperature difference from the coolant inlet to outlet along the flow path (Figure 5).

The flow rate through the cold plates and inlet coolant temperature will be held constant during any particular test run. These parameters will be varied, however, for different charge and discharge rates to provide an accurately detectable temperature gradient from inlet coolant to outlet coolant and to maintain the cell case temperature at the desired test levels irrespective of charge and discharge rates.

Math Model of Calorimeter: It can be shown that, for a one time constant system, the instantaneous cell heat generation rate can be related to the coolant flow rate and the inlet coolant to outlet coolant temperature gradient by the equation

$$q_{GEN} = \frac{WC_p\left[T_{outlet\,(t=t)} - T_{outlet\,(t=0)}\right]}{1 - e^{-t/\tau}} + WC_p\left[T_{outlet} - T_{inlet}\right]_{t=0}$$

Where, q_{GEN} = average heat generation rate for t=o to t=t, BTU/HR.

W = mass flow rate, #/hr.

C_p = coolant specific heat, (see Figure 1)

τ = system time constant, hours, (function of W)

T_{OUTLET} = outlet coolant temperature, $^{\circ}F$

T_{INLET} = inlet coolant temperature, $^{\circ}F$ (constant)

t = time, hrs.

Any continuously varying curve of T_{outlet} vs. time can be transformed into a heat generation rate curve if W and τ are known. By dividing the T_{outlet} curve into discrete time increments and applying the above equation (by setting $t = 0$, at the start of each increment), the average heat generation rate during that interval can be established.

The experimental data from the test program will include T_{outlet} as a function of time and W for each test run. In addition, calibration runs will be performed to determine the value of τ for each flow rate setting. This will be done by using one of the heater cells constructed for this program. (These are live 100 amp-hour cells which have internal resistive heaters and an extra pair of terminals on the heater). The heater will be energized to provide a constant heat generation rate, and the coolant outlet temperature monitored until thermal equilibrium is achieved. When this occurs, power to the heater will be terminated, and the temperature decay curve of the coolant outlet will be recorded. It can be shown that:

$$\tau = \frac{\int_{t=0}^{t=t} T_{outlet}\, dt}{(T_{outlet} - T_{inlet})_{t=0}}$$

Thus, integrating the decay curve and dividing by the initial temperature gradient along the flow path will yield the system time constant, τ.

The above data reduction method will be applied by Eagle Picher in the interpretation of the raw test data.

2.0 APPLICABLE DOCUMENTS

2.1 GAC

Purchase Order 0-15161

AV-D559CS-1; 100 A-H Ni-CD Storage Cells Specification

2.2 Eagle-Picher Industries, Inc.

DVTP-153-1 Test Plan, Part 1, Cell Development Tests

EP-QC-1157 Calibration Procedure Manual

3.0 REQUIREMENTS

3.1 Equipment

ITEM	MFG.	MODEL NO.
Data Acquisition System GAC Supplied	Non-Linear System	200 Channel Punched Paper Tape & Digital Printer Readout
Temp. Controlled Chamber	Missimers	FT-8-100x350
Power Supply, DC	Harrison	6268A
Power Supply, DC	Sorenson	DCR40-60A
Ammeter (0-100 Amp Range)	Weston	
Ammeter (0-100 Amp Range)	Weston	
Charger-Cycler Combination	E-P	CGR-2003-2006 Combination or Equivalent
Thermocouple Bridge	Thermo-Electric	70200
Precision Potentiometer	Leeds & Northrup	8687

Equivalent equipment is permissible. This refers to the capability of the specified equipment with respect to range, magnitude, accuracy and resolution.

Any such change shall be reported to Grumman with the test data, and such data shall be stamped, or otherwise identified as "PRELIMINARY, APPROVAL PENDING" until approved by Grumman. Approval or comments shall be given by Grumman within fifteen (15) days of receipt of such data.

3.2 Test Conditions

Except where otherwise noted, test conditions shall be as follows:

3.2.1 Temperature (Monitored and Recorded)

Cell Case: $20^{\circ}C \pm 3^{\circ}C$ ($68 \pm 5^{\circ}F$); $0^{\circ}C \pm 3^{\circ}C$ ($32^{\circ}F \pm 5^{\circ}F$)

Coolant Inlet: Consistent with cell case temperature requirements, constant to $\pm 0.5^{\circ}F$

3.2.2 Barometric Pressure

Ambient (28-31 inches mercury)

3.2.3 Humidity, Relative

Ambient

3.3 Accuracy of Test Apparatus

As a minimum, accuracy of equipment shall be as follows:

3.3.1 Visually Read Ammeters

$\pm$ 0.5% Full Scale (With Anti-Parallax Scales)

3.3.2 Visually Read Voltmeters

$\pm$ 0.5% Full Scale (With Anti-Parallax Scales)

3.3.3 200 Channel NLS Data Acquisition System

Four significant figures with a resolution of ± 1 on the least significant digit, and an absolute accuracy of reading $\pm$ 0.5% of the reading maximum.

3.3.4 Temperature

$\pm 0.5^{\circ}F$

3.3.5 Digital Recorded Voltage

Same as 3.3.3.

3.3.6 Instruments of Less Accuracy shall be used as "Indicator Only"

3.4 Instrumentation

All voltage, temperature, current, and pressure data will be recorded and monitored using the NLS data acquisition system supplied by GAC. The data will be recorded on punched paper tape, printed out in real time on paper tape and recorded on data sheets for monitoring purposes. Each measurement must be sampled and recorded a minimum of at least once every 60 seconds on the punched tape, at least once every 5 minutes on the printed tape, and at least once every 15 minutes on the data sheets.

3.4.1 Temperature

The test set-up will be instrumented with, but not be limited to the thermocouple and/or thermopile (ΔT) measurements described below. (All thermocouples will be fine gauge copper constantin).

Channel #	Location	
1	Common Coolant Inlet (Figure 5)	
2-5	Each cold plate's coolant outlet, approx. $\frac{1}{2}$" from cold plate (Figure 5)	
6	(T_2-T_1), ΔT on coolant leg	(Figure 5)
7	(T_3-T_1), ΔT on coolant leg	
8	(T_4-T_1), ΔT on coolant leg	
9	(T_5-T_1), ΔT on coolant leg	
10	Room Ambient (Figure 5)	

Channel #	Location
11	Air Chamber (Figure 5)
12	Coolant Reservoir (Figure 5)
13-18	Cold Plate Face (Cell face) temperatures (Figure 6)
19-20	On main current leads to calorimeter
21-22	On voltage and current sensing harness to calorimeter
23	Sum of six thermocouples; inside of each face of insulation
24	Sum of six thermocouples; one on outside of each face of insulation

The digital recording equipment (NLS System) will be used to measure all temperature readings. The amplifier will be set at approximately 1000 x but will be adjusted using a L+N potentiometer for standardizing and calibrating periodically during operation if required.

A ± 0.5 millivolt (full scale) nulling potentiometer will be used to sense the differences in temperature between channel #'s 19 and 20 (main current lead temperatures), 21 and 22 (instrumentation lead temperatures), and 23 and 24 (calorimeter insulation temperatures). These signals will be used to activate and deactivate guard heaters on the leads and the cooling control on the calorimeter's air chamber, respectively.

3.4.2 Other Instrumentation

Channel #	Location
25	Current to (or from) cell (including heater current)
26	Cell voltage (heater or live cell)

Channel #	Location
27	Auxiliary electrode signal voltage
28	Pressure transducer (if delivered to EP by NASA/GSFC)
29	AH integrator (if delivered to EP by NASA/GSFC)

All voltage, current, pressure and ampere-hour readings will be recorded on the NLS digital data acquisition system.

An event timer shall be used with the data acquisition system so that test time is recorded for every measurement scan.

3.5 Documentation

A final report will be issued within thirty (30) days of the completion of testing. The report will contain copies of all the raw data collected during the entire test, complete equipment and instrumentation lists (per paragraphs 3.1 and 3.4), and the results of the raw data interpretation into heat generation rate data per the method discussed in Section 1.1.

A preliminary copy of the test data will be supplied to Grumman after each test run, upon request, as it becomes available.

4.0 TEST PROCEDURES

In the test runs below, the terms "stabilization" and "repeatable periodic trace" are used as conditions to be met prior to the start and/or the termination of a test run.

When used below, "stabilization" shall be understood to mean that successive temperature readings on the same thermocouple taken over a 45 minute period show a change of less than 0.5°F over the entire period.

The phrase "repeatable periodic trace" when applied as a criteria for terminating a cyclical test condition shall mean that two successive readings of the same thermocouple at the same relative point on two successive orbits shall differ by no more than ±0.5°F and the end of discharge terminal voltage on two successive orbits are the same to within ±0.005 volts.

4.1 Calibration Runs

Calibration runs will be performed, using one of the program's 100 Ampere-Hour heater cells, in which predetermined quantities of heat will be released into the calorimeter at known rates. These runs will provide information on:

(a) the effectiveness of the guard heaters (on the current and sensor leads) and the insulation (surrounding the calorimeter) in minimizing the heat leaks out of the calorimeter,

(b) the temperature difference between the cell's reference temperature (three inches from the bottom of the broad face, equidistant from each terminal) and the coolant inlet temperature as a function of heat generation rate and coolant flow rate,

(c) the thermal time constant (thermal log) of the calorimeter systems,

(d) the required ratio of narrow cold plate to broad cold plate (see figure 2) coolant flow rate for equal temperature rise (inlet to outlet) on each.

Three calibration runs will be performed for each of two coolant inlet temperature levels (see table 1 below). One or more of these runs may be repeated to demonstrate repeatability if required by the test engineer.

TABLE 1

Run #	Coolant* Inlet Temperature °F	Heater Power, watts	Coolant* Flow Rate, lb/hr		
			Total (4 cold plates)	Narrow Plate	Broad Plate
1	22.	16.0	8.0	.670	3.33
2	22.	9.0	4.5	.370	1.88
3	22.	4.0	2.0	.167	0.833
4	58.	16.0	8.0	.670	3.33
5	58.	9.0	4.5	.370	1.89
6	58.	4.0	2.0	.167	0.833

*Coolant is a 35% (by weight) ethylene glycol solution.

After installing the heater cell in the calorimeter (see figures 2,3, 4, and 5) each of the calibration runs will be performed as outlined below.

A calibration run will consist of the following steps:

(a) Circulate the coolant through the calorimeter at the constant inlet temperatures and pre-determined flow rates shown in table 1 above until stabilization is achieved (guard heater circuits active),

(b) supply a constant wattage to the heater cell's inconel heater element per table 1 above,

(c) monitor all system temperatures and flow rates until stabilization has been achieved,

*(d) if required by the test engineer re-adjust the flow rate ratio between the narrow and broad cold plates to achieve an $8^{o}F$ temperature gradient from coolant inlet to coolant outlet in each leg. (If such an adjustment is required, record the new narrow to broad cold plate flow rate ratio and revise the flow rates in table 1 to conform with this new ratio).

*(e) if step (d) is required, monitor all system temperatures and flow rates until stabilization has been achieved.

(f) remove power from cell heater and monitor system temperatures and flow rates until stabilization occurs.

*steps (d) and (e) will be performed only on runs #1 and #4 (table 1).

4.2 Calorimetry Runs

Two 100 ampere-hour cells (S/N 16 and 22) will be tested in the calorimeter. One cell (S/N 16) is of a "thin electrode" design while the other cell (S/N 22) has terminals on opposite ends of the cell case.

Each cell will be tested at two cell temperature levels and three simulated orbital regimes as defined in table 2 below. A total of twelve (12) calorimetry runs (6 per cell) will therefore be performed. A minimum of four continuous orbits will be run at each condition even if repeatable orbital measurements occur sooner. Charge and discharge control will be accomplished with the circuit shown in figure 7. (Appendix 1 describes the means whereby two Sorenson DCR 40-60A power supplies may be used in parallel to automatically control the discharge current to the constant levels shown in Table 2 below).

TABLE 2

Run #	Cell Temperature, °F	Coolant Inlet Temp., °F	Depth-of-Discharge,%	Charge* Rate, amps.	Charge* Time, min.	Discharge* Rate, amps	Discharge* Time, min
1	68	To be consistent	50	62.2	58.	83.3	36
2	68	with the	12	14.5	58.	20.	36
3	68	results of the	30	37.4	58.	50.	36
4	32	calibration	50	62.2	58.	83.3	36
5	32	tests. See	12	14.5	58.	20.	36
6	32	para. 4.1.6)	30	37.4	58.	50.	36

*Charge and discharge shall be performed at a constant current rate (see circuit figure 7). If end-of-charge voltage limit (1.56 volts @ 32°F, 1.51 volts @ 68°F) is reached before charge time has expired, charging shall continue at constant potential (tapered charge).

All data will be continuously recorded by the NLS system and on the data sheets whenever the calorimetry cooling systems are active per paragraph 3.4 (with the sole exception that if test delays result in long periods (greater than 3 hours) between test runs the data sampling rate may be reduced to once every 30 minutes).

The following detailed steps (a through ff) shall be performed on each of the test cells.

(a) The cell shall be removed from storage (where it has been kept in a shorted condition) one to two days prior to the planned start of calorimetric testing on that cell.

(b) The restrained cell will be given one conditioning cycle as follows:

1. charge at a 10 ampere rate for 16 hours or until a terminal voltage of 1.51 volts is reached* (whichever occurs first),
2. follow immediately with a discharge at a 50 ampere rate to an end voltage of 1.0 volts.

* Or if 100 psig is reached (if pressure can be monitored)

(c) The cell will be installed in the calorimeter (figures 2 through 5) and the calorimeter system configured for the start of test run #1 (table 2). Coolant flow and active temperature control of the system will be initiated.

(d) The cell will remain on open circuit with the temperature control system active until temperature stabilization has been achieved.

(e) The cell will be brought to a full state of charge by charging at a 30 ampere rate for 5 hours or until a terminal voltage of 1.51 volts is reached* (whichever occurs first).

(f) The cell will immediately begin continuous cycling to the orbital parameters defined in table 2, run #1 (starting with a discharge).

(g) Cycling will continue until a repeatable periodic trace has been established on all measurements (for a minimum of four orbits).

(h) The cell will be open circuited at the end of the last orbital discharge period and all data will be monitored until thermal stabilization occurs.

(i) The cell will be brought to a full state of charge by charging at the table 2, run #1 charge rate until a voltage of 1.51 volts has been reached.* Simultaneously, the calorimeter flow rates and set temperatures will be adjusted for run #2.

(j) Immediately upon reaching full charge, the cell will begin continuous cycling to the orbial parameters defined in table 2, run #2 (starting with a discharge).

(k) Cycling will continue until a repeatable periodic trace has been established on all measurements (for a minimum of four orbits).

(l) The cell will be open circuited at the end of the last orbital charge period and all data will be monitored until thermal stabilization occurs.

* Or if 100 psig is reached (if pressure can be monitored)

(m) The cell will be brought to a full state of charge by charging at the table 2, run #2 charge rate until a voltage of 1.51 volts has been reached (a topping charge). Simultaneously, the calorimeter flow rates and set temperatures will be adjusted for run #3.

(n) Immediately upon reaching full charge, the cell will begin continuous cycling to the orbital parameters defined in table 2, run #3 (starting with a discharge).

(o) Cycling will continue until a repeatable periodic trace has been established on all measurements(for a minimum of four orbits).

(p) Immediately following the end of the last orbital charge period, the cell will be discharged at a 50 ampere rate to an end voltage of 1.0 volts. This will be immediately followed by a charge at a 30 ampere rate for 5 hours or a terminal voltage of 1.51 volts * (whichever occurs first). The cell will then be open circuited.

(q) Following step (p) above, the test may be interrupted for a convenient period at the test engineer's option.

(r) The calorimeter system will be configured for the start of test run #4 (table 2). Coolant flow and active temperature control of the system will be reinitiated (if the system was shut down after step p).

(s) The cell will remain on open circuit with the temperature control system active until temperature stabilization has been achieved.

(t) The cell will be brought to a full state of charge by charging at a 30 ampere rate until a voltage of 1.56 volts has been reached* (a topping charge).

(u) The cell will immediately begin continuous cycling to the orbital parameters defined in table 2, run #4 (starting with a discharge).

* Or if 100 psig is reached (if pressure can be monitored)

(v) Cycling will continue until a repeatable periodic trace has been established on all measurements (for a minimum of four orbits).

(w) The cell will be open circuited at the end of the last orbital charge period and all data will be monitored until thermal stabilization occurs.

(x) The cell will be brought to a full state of charge by charging at the table 2, run #4 charge rate until a voltage of 1.56* volts has been reached (a topping charge). Simultaneously, the calorimeter flow rates and set temperatures will be adjusted for run #5.

(y) Immediately upon reaching full charge, the cell will begin continuous cycling to the orbital parameters defined in table 2, run #5 (starting with a discharge).

(z) Cycling will continue until a repeatable periodic trace has been established on all measurements (for a minimum of four orbits).

(aa) The cell will be open circuited at the end of the last orbital discharge period and all data will be monitored until thermal stabilization occurs.

(bb) The cell will be brought to a full state of charge by charging at the table 2, run #5 charge rate until a voltage of 1.56* volts has been reached. Simultaneously, the calorimeter flow rates and set temperatures will be adjusted for run #6.

(cc) Immediately upon reaching full charge, the cell will begin continuous cycling to the orbital parameters defined in table 2, run #6 (starting with a discharge).

(dd) Cycling will continue until a repeatable periodic trace has been established on all measurements (for a minimum of four orbits).

* Or if 100 psig is reached (if pressure can be monitored)

(ee) Immediately following the end of the last orbital charge period, the cell will be discharged at a 50 ampere rate to an end voltage of 1.0 volts. This will be immediately followed by a charge at a 30 ampere rate for 5 hours or a terminal voltage of 1.51 volts * (whichever occurs first). The cell will then be open circuited, concluding the calorimetric tests on the cell.

(ff) repeat steps (a) through (ee) on the second test cell.

* Or if 100 psig is reached (if pressure can be monitored)

FIGURE No. 1
Specific Heat Vs. Temperature

35% by weight Ethylene Glycol-water

Ref: Union Carbide Corporation
Research Department

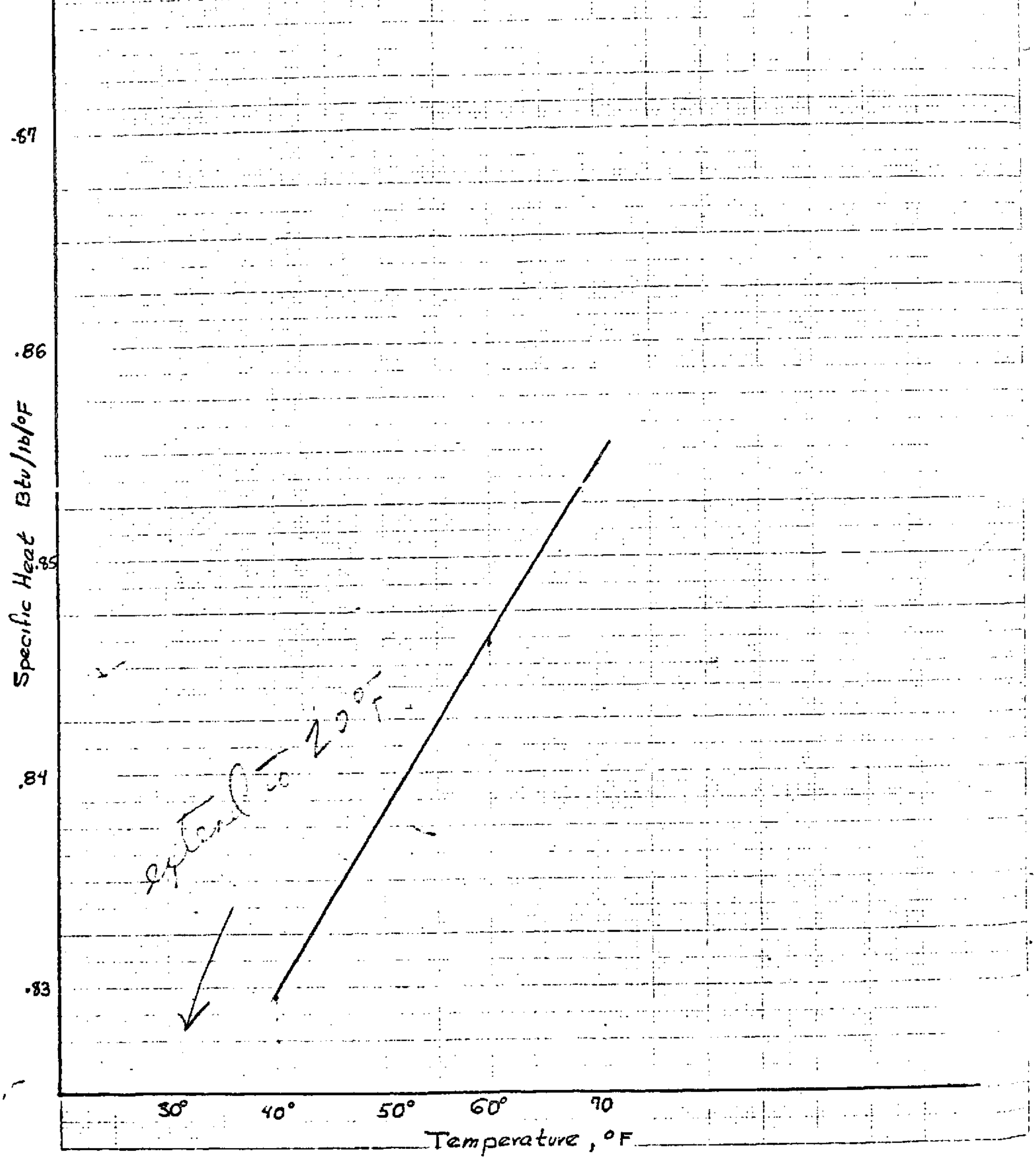


FIGURE NO. 2

COLD PIATES

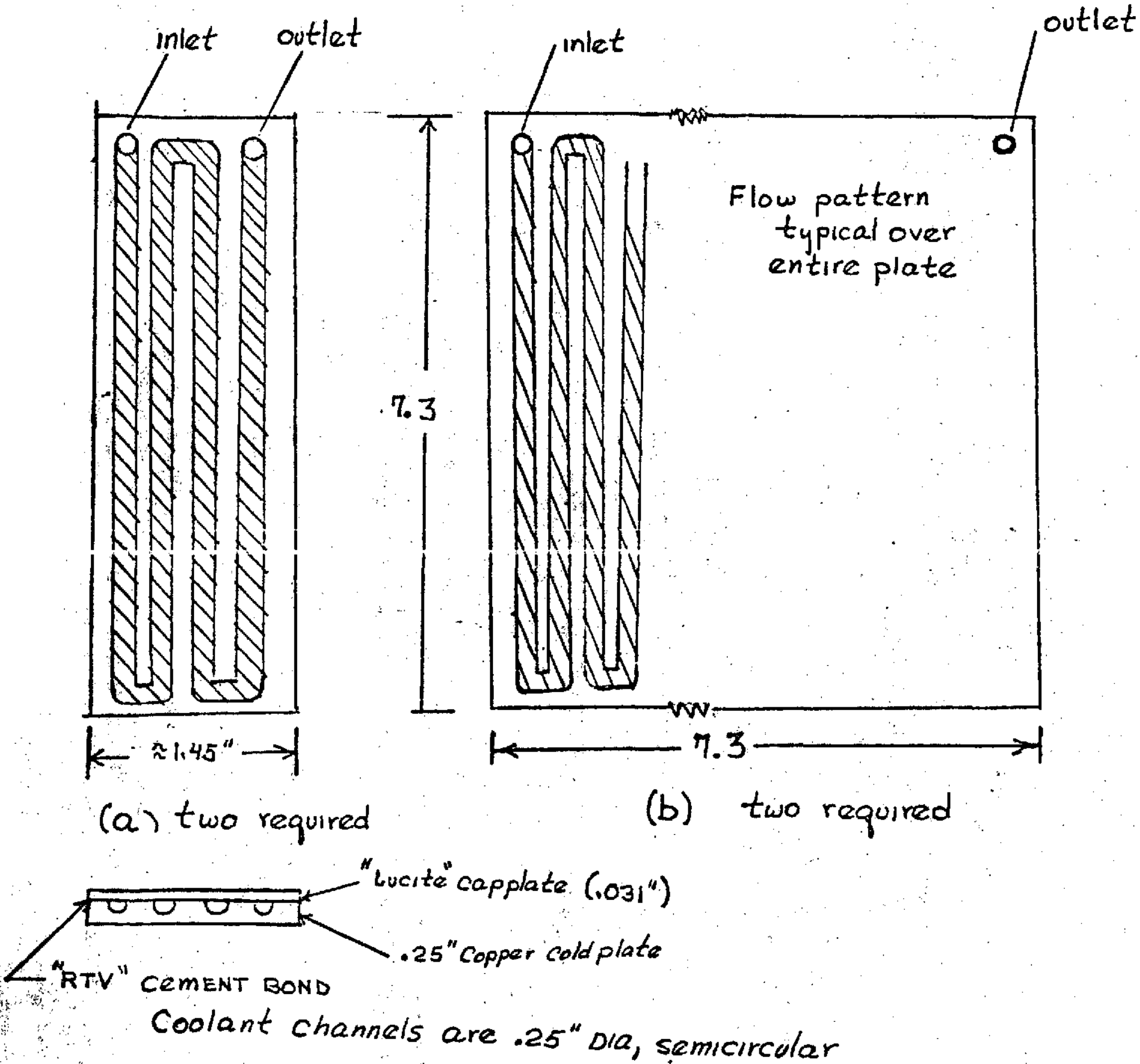
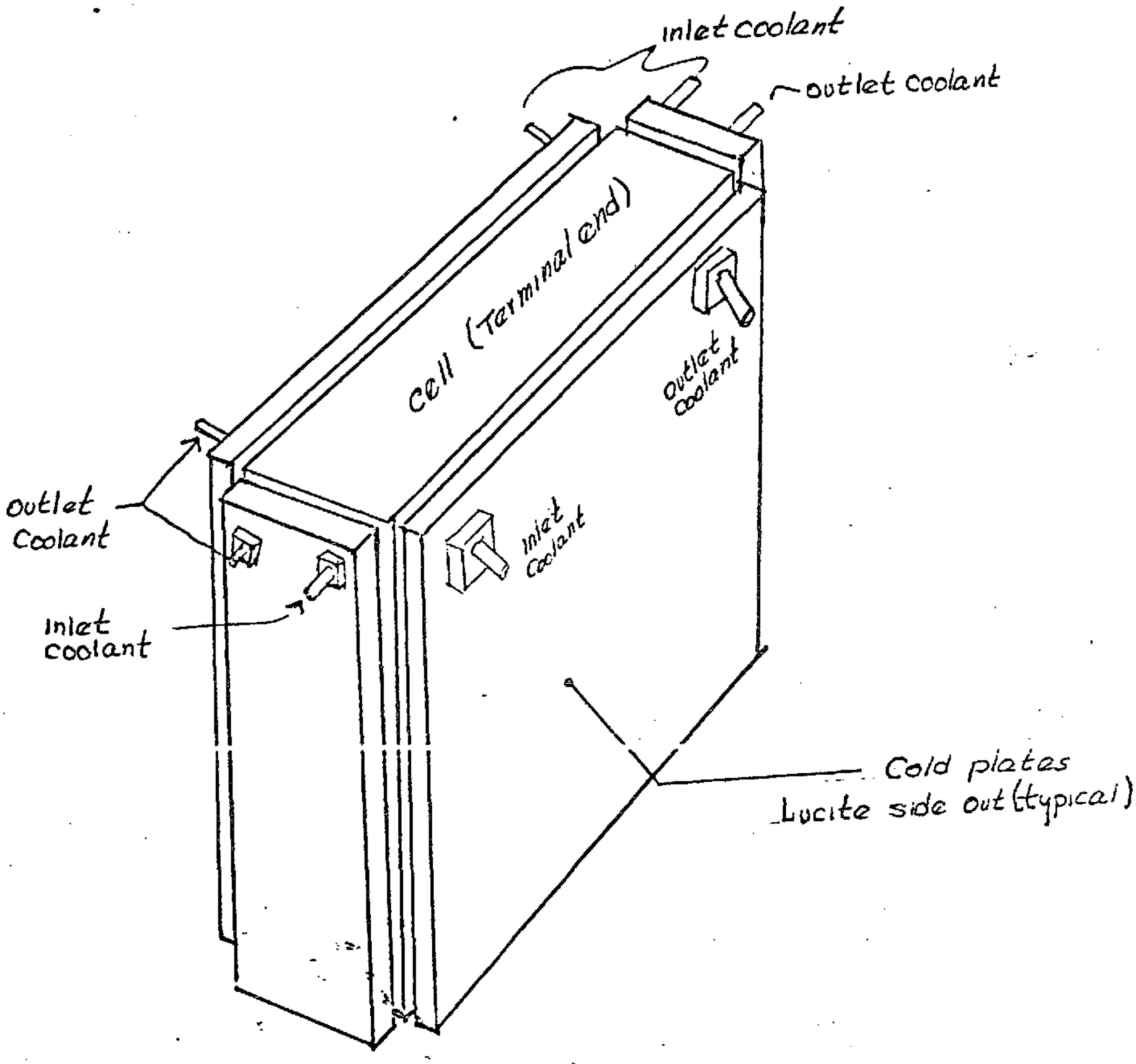
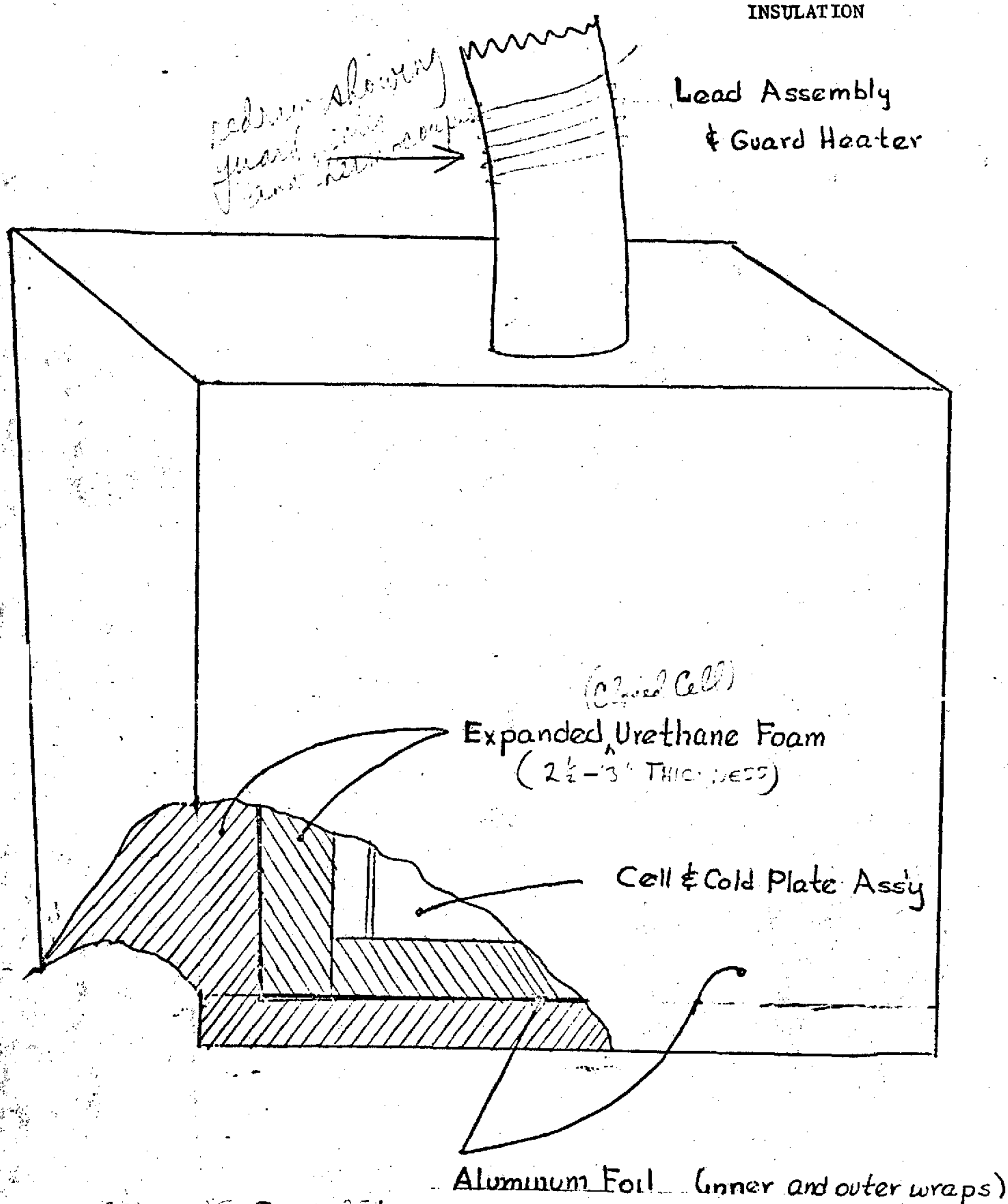


FIGURE 3
COLD PLATE ASSEMBLY



Cold plate assemblies are restrained by 3/4" aluminum angle braces

FIGURE 4
INSULATION



TEMPERATURE SENSORS:

a) ONE THERMOCOUPLE LOCATED ON INNER AND OUTER SURFACE OF EACH INSULATION FACE (12 TOTAL) — (INPUT TO CHAMBER AIR TEMPERATURE CONTROL CIRC

b) FOUR THERMOCOUPLES LOCATED ON ELECTRICAL LEADS (INPUT TO GUARD HEATER CONTROL CIRCUIT)

FIGURE 5

COOLANT FLOW SCHEMATIC AND TEMPERATURE SENSOR LOCATIONS

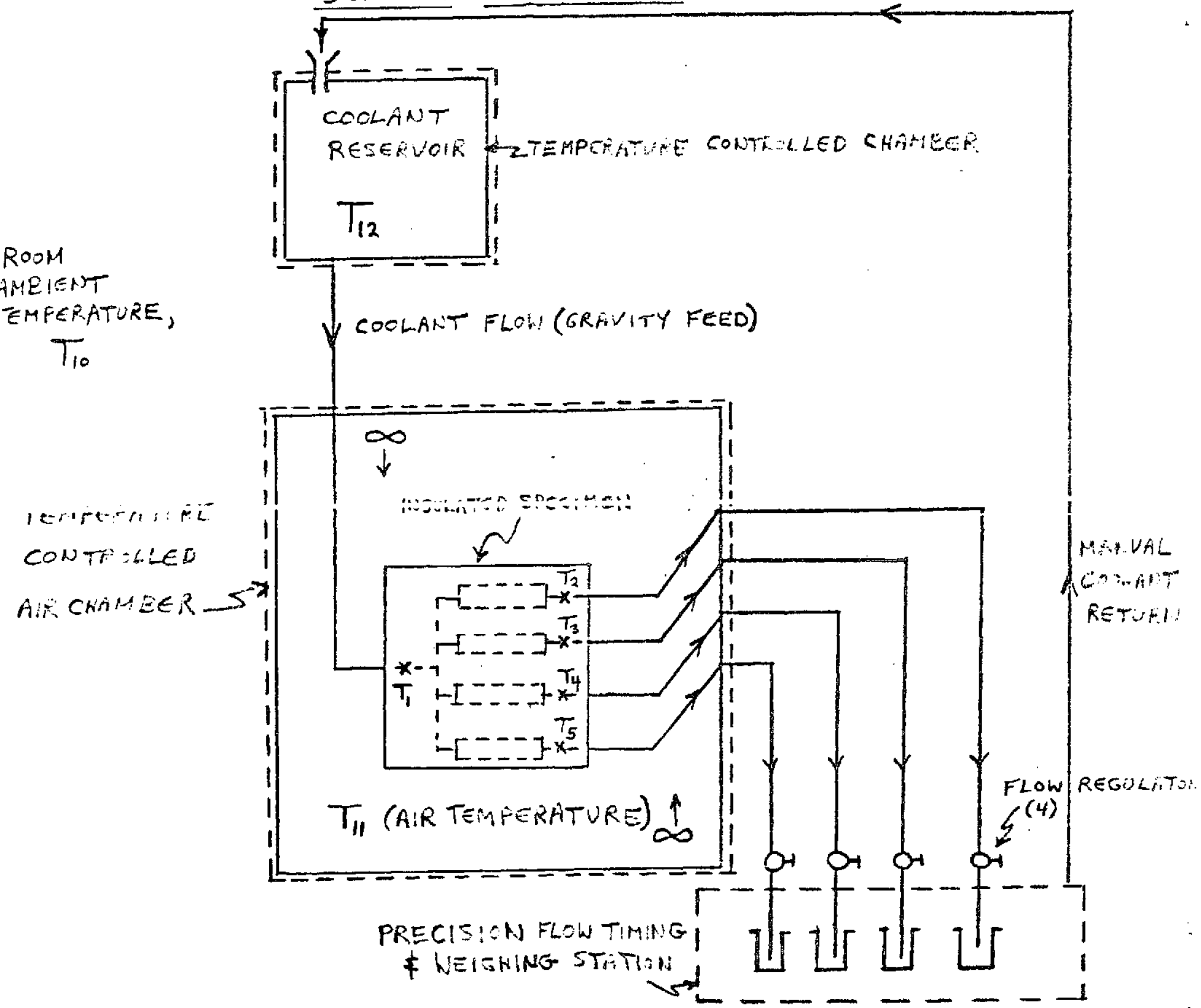
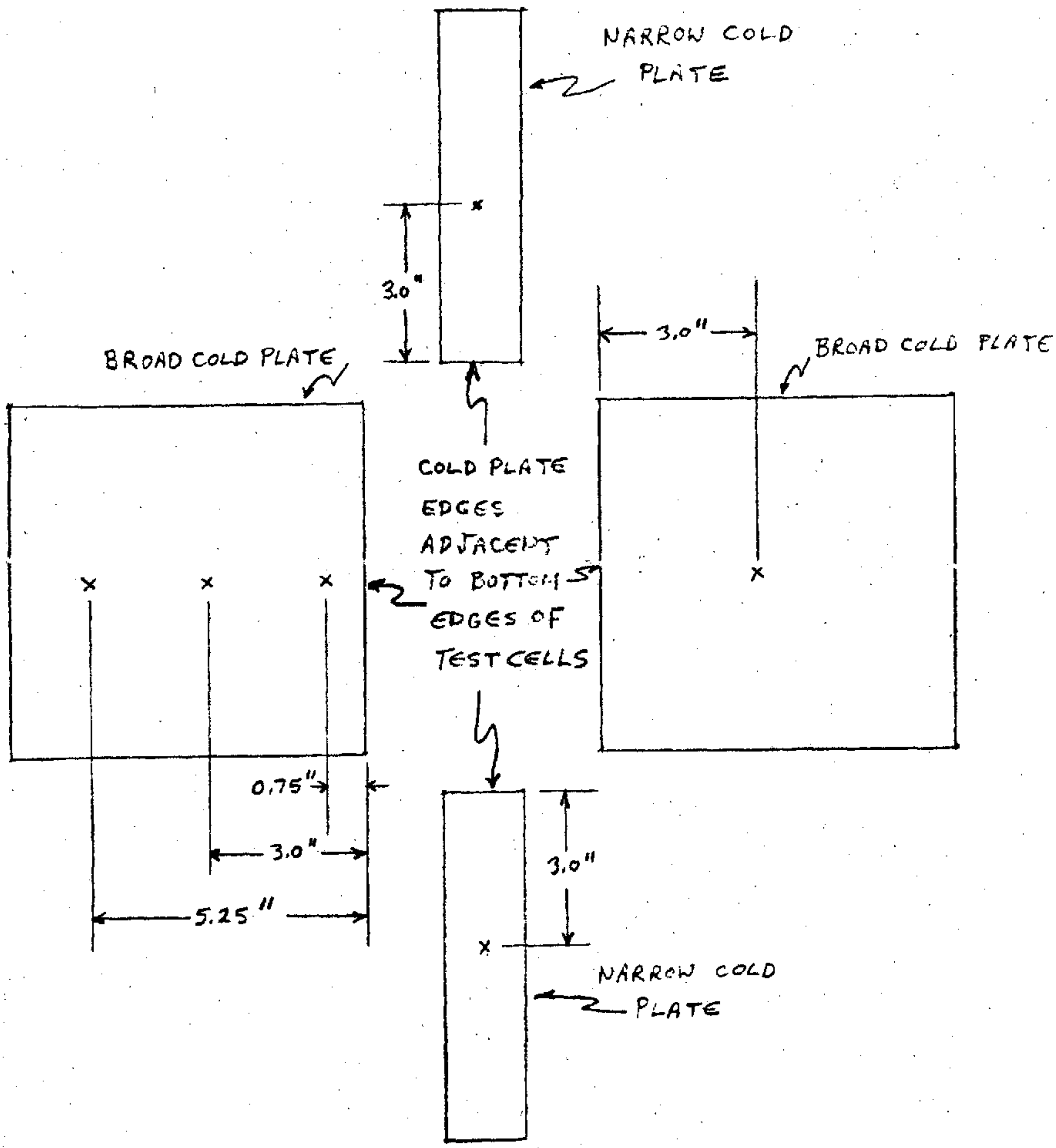
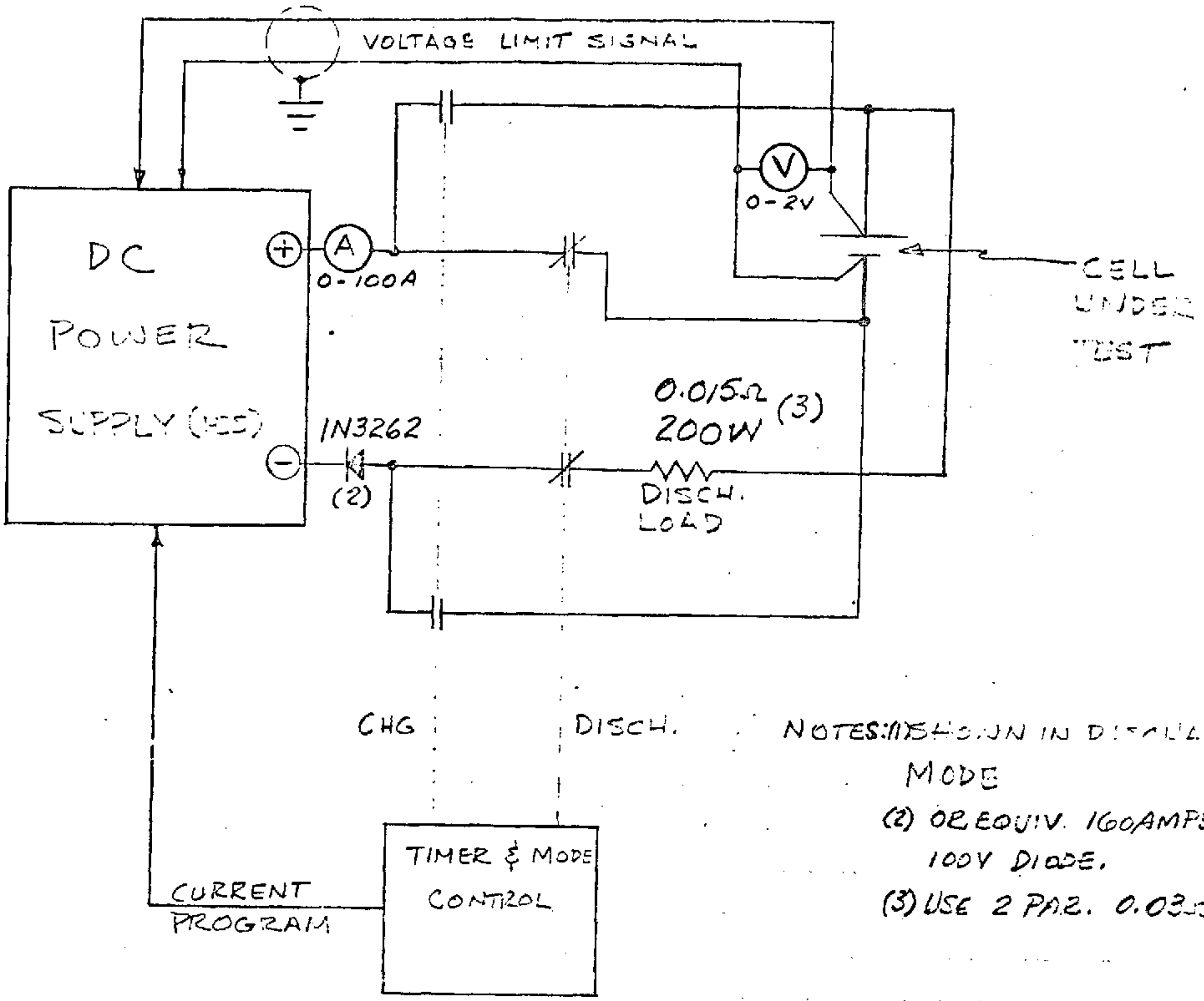


FIGURE 6

THERMOCOUPLE LOCATIONS* ON FLAT COLD PLATES



* NOTE: EACH THERMOCOUPLE (FINE GAGE CU-CN) TO BE LOCATED IN A GROOVE SCRIBED INTO COPPER FACE OF ITS COLD PLATE. THERMOCOUPLE BEADS TO BE SUPPORTED ON A CURED DAB OF RTV MATERIAL (6 TOTAL)



NOTES: (1) SHOWN IN DISCHARGE MODE
(2) OR EQUIV. 160 AMPERE, 100V DIODE.
(3) USE 2 PAR. 0.03Ω, 100W

FIGURE 7

BLOCK DIAGRAM -- CHARGE/DISCHARGE CONTROL

EAGLE-PICHER INDUSTRIES, INC.

Couples Plant - Joplin, Missouri

TYPE TEST: Calibration Heating

TEST SPECIMEN NO. ____________

TEST PROCEDURE NO. ____________

TEST PARA. REF. NO. ____________

AMBIENT TEMP. ________ °F

BATT. TEMP. ________ °F

DATE ____________ TIME ____________

E. P. BAT. TYPE ____________ S. N. ____________

____________ BAT. NO. ____________

TYPE PROGRAM: PROD. ☐ QUAL. ☐ R & D ☐

PREVIOUS TEST: ____________

	$\underbrace{\qquad\qquad}_{\text{[illegible]}}$		$\underbrace{\qquad\qquad}_{T_1 \to T_5}$			Flow					
						FW1	W2	W3	W4		
TIME	VOLTS	AMPS	T	T_5	T_6	~~TIME~~	~~VOLTS~~	~~AMPS~~			
1 min											
15 min											
30 min											
45 min											
1 Hr											
15 min											
30 min											
45 min											
2 hr											
15 min											
30 min											
45 min											
3 hour											
15 min											
45 min											
4 Hr											
5 Hr											

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant - Joplin, Missouri

TYPE TEST: Calibration Decay

TEST SPECIMEN NO. ______

TEST PROCEDURE NO. ______
TEST PARA. REF. NO. ______
AMBIENT TEMP. ______ °F
BATT. TEMP. ______ °F

DATE ______ TIME ______
E. P. BAT. TYPE ______ S. N. ______
______ BAT. NO. ______
TYPE PROGRAM: PROD. ☐ QUAL. ☐ R & D ☐
PREVIOUS TEST: ______

Flow
EACH 15 MINUTES

TIME	VOLTS	AMPS	T_1	T_2	T_3	W_1 ~~TIME~~	W_2 ~~VOLTS~~	W_3 ~~AMPS~~	W_4		
1min											
5min											
10 min											
15 min											
30 min											
45 min											
1 Hr											
15 min											
30 min											
45 min											
2 Hr											
15 min											
30 min											
45 min											
3 Hr											
4 Hr											
5 Hr											
6 Hr											

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

EAGLE-PICHER INDUSTRIES, INC.
Couples Plant - Joplin, Missouri

TYPE TEST: ~~Charge~~ FULL DISC[illegible] /CHARGE (T[illegible]) TEST SPECIMEN NO. ______

TEST PROCEDURE NO. ______ DATE ______ TIME ______
TEST PARA. REF. NO. ______ E. P. BAT. TYPE ______ S. N. ______
AMBIENT TEMP. ______ °F ______ BAT. NO. ______
BATT. TEMP. ______ °F TYPE PROGRAM: PROD. ☐ QUAL. ☐ R & D ☐
PREVIOUS TEST: ______

CONFIGURE A SHEET TO RECORD
$T_1 \rightarrow T_5$ & all flowrates for 50A discharge/30A charge
[illegible]

						Flow					
TIME	VOLTS	AMPS				~~TIME~~	~~VOLTS~~	AMPS			
1 min											
15 min											
30 min											
45 min											
1 Hr											
15 min											
30 min											
45 min											
2 Hr											
15 min											
30 min											
45 min											
3 Hr											
15 min											
30 min											
45 min											
4 Hr											
5 Hr											
6 Hr											
7 Hr											
8 Hr											
9 Hr											
10 Hr											
Top Charge											
1 min											
5 min											
10 min											
15 min											
20 min											
25 min											

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

Data Sheet 4
Cycle

EAGLE-PICHER INDUSTRIES, INC.

Couples Plant - Joplin, Missouri

TYPE TEST: LAST Cycle ([illegible]) TEST SPECIMEN NO. ______

TEST PROCEDURE NO. ______ DATE ______ TIME ______

TEST PARA. REF. NO. ______ E. P. BAT. TYPE ______ S. N. ______

AMBIENT TEMP. ______°F ______ BAT. NO. ______

BATT. TEMP. ______°F TYPE PROGRAM: PROD. ☐ QUAL. ☐ R & D ☐

PREVIOUS TEST: ______

CHARGE OR DISCHARGE MAY OCCUR FIRST (DEPENDS ON TEST RUN — SEE PROCEDURES)

MEASURE EACH 15 MINUTES

Flow

TIME	VOLTS	AMPS	T_1 T_2	T_3	T_5	TIME (W_1)	VOLTS (W_2)	AMPS (W_3)	(W_4)		
Discharge											
1min											
5 min										x	
10 min											
15 min										x	
20 min											
25 min										x	
30 min											
35 min										x	
[illegible]											
Charge											
1min										x	
5 min											
10 min											
15 min											
20 min										x	
25 min										x	
30 min											
35 min										x	
40 min											
45 min											
50 min										x	
55 min											

	Voltmeter	Ammeter
TYPE		
MODEL		
S/N		
CALIB. FACTOR		
CALIB. DUE DATE		
OPERATOR		
ENGINEER		
INSPECTOR		

APPENDIX I

A SUGGESTED CHARGE/DISCHARGE CIRCUIT--THEORY OF OPERATION

Figure A shows a circuit whereby two (2) Sorensen power supplies, Model DCR40-60A, are paralleled and operated in the current-controlled, externally programmed mode with preset voltage limit. The circuit further demonstrates a technique for using the supplies as a controlled current source for both charge and discharge operation, and the interfacing to an electromechanical timer with closure outputs.

The circuit operates as follows:

1. ENTRY INTO, AND CONTINUATION OF, CHARGE: Upon receipt of the closure command from the timer, K3S is energized, causing K3A and K3B contacts to close. Closure of K3A causes discharge current to be programmed to 5 amperes. 100 milliseconds later (delay generated by the transistor circuit), K7 closes, opening all K2's, and immediately afterward, all K1's close. K5 also closes, resetting K3, and allowing the charge current to rise to the preset value. Charge continues at the desired rate until the cell voltage reaches the limit value, at which time, the paralleled supplies shift to a voltage-controlled mode, causing the charge rate to taper.
2. ENTRY INTO, AND CONTINUATION OF, DISCHARGE: Similar action to that described above occurs, starting with K4S. The major difference is that the voltage limit does not come into play since cell voltage is dropping.
3. OPERATION OF S2: S2 is used to change the current programming levels to test the cell to the 50%, 30% and 12% Depths-of-Discharge, respectively. The switch must be make-before-break to avoid open-circuiting the supplies' current control circuit.

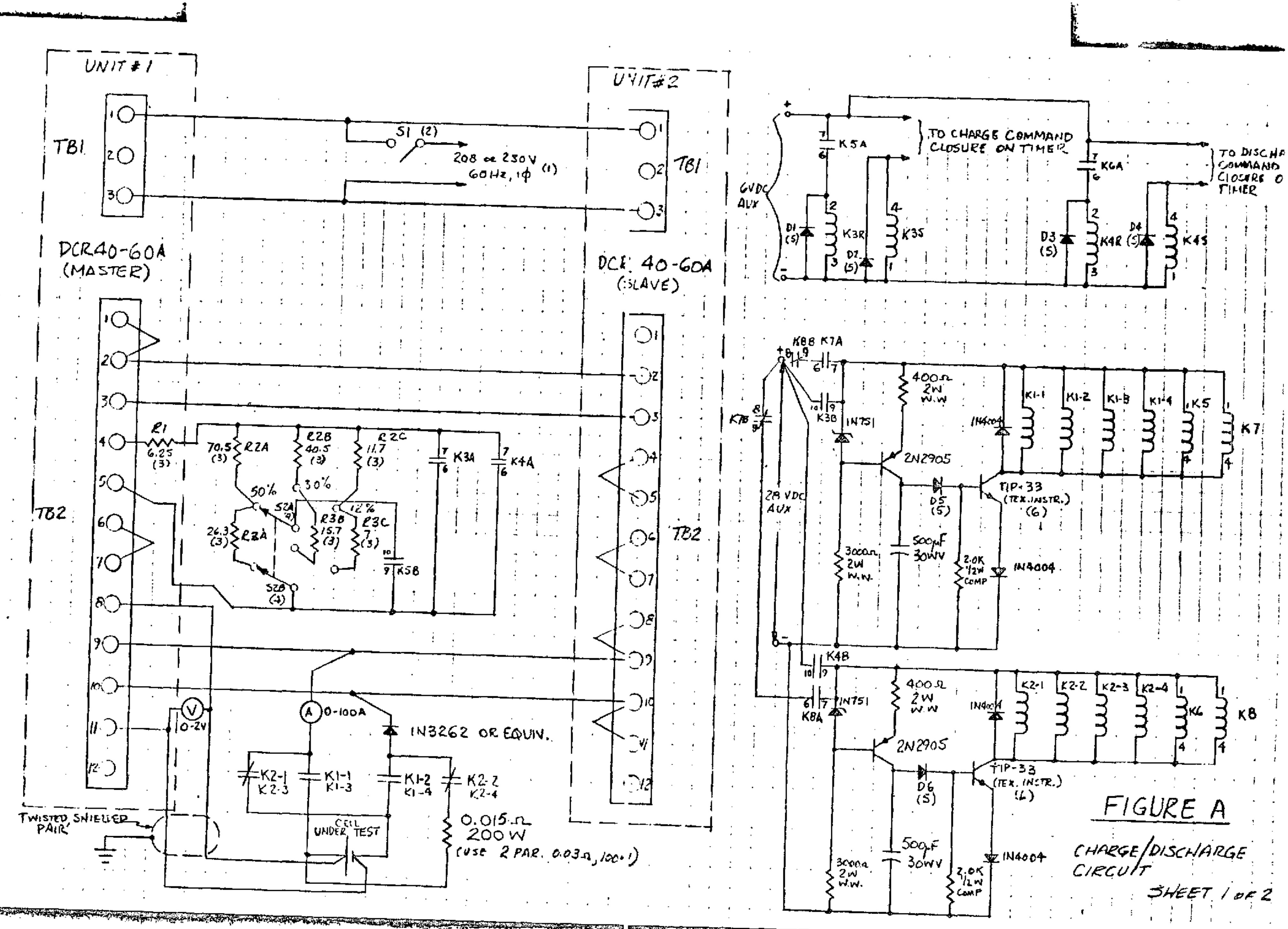


FIGURE A

CHARGE/DISCHARGE CIRCUIT

SHEET 1 of 2

NOTES

(1) Wire input transformer of each power supply for appropriate input voltage per Sorensen Instruction Manual.

(2) S1: SPST, 230VCKT, 25AMP Min. Rating.

(3) All resistors in current programming circuit are approximate, based on published nominals of 2.5Ω/Ampere/Unit. Adjust each resistor for particular units used as follows:

- (a) All R2's & R3's shorted: Adjust R1 for I_o=5AMP
- (b) R1&R2A in circuit, R3A shorted: Adjust R2A for I_o=62.2 AMP.
- (c) R1, R2A&R3A in circuit: Adjust R3A for I_o=83.3 AMP.
- (d) R1&R2B in circuit, R3B shorted: Adjust R2B for I_o=37.4 AMP.
- (e) R1, R2B&R3B in circuit: Adjust R3B for I_o=50.0 AMP.
- (f) R1&R2C in circuit, R3C shorted: Adjust R2C for I_o=14.5 AMP.
- (g) R1, R2C&R3C in circuit: Adjust R3C for I_o=20.0 AMP.

Use 10W, W.W. Adj. Slider Units

(4) S2: 2-Wafer, 3 position rotary switch, make-before-break for both directions.

(5) D1 thru D6: IN645, IN914, IN4148, or equiv.

(6) Mount Tip-33's on 4"x 4"x 1/16" heat sink each.

(7) K1's & K2's: 50 AMP contact, SPST, DB, NO, 24V @ 400 coil, magnecraft mod. W88KDX-3 or equiv., (8) req'd.

(8) K3, K4: Magnetic latching relay, DPDT, 6V @ 100 (SET) & 36 (RESET) coils, Potter-Brumfield Mod. R30-E1-Z2-V36-100 or equiv., (2) req'd.

(9) K5 thru K8: DPDT, 24V @ 700 coil, Potter-Brumfield mod. R10-E1-Z2-V700 or equiv., (4) req'd.

(10) Adjust voltage limit on unit #1 (Master) only to:

- (a) 1.51V for 20°C Tests
- (b) 1.56V for 0°C Tests

FIGURE A

CHARGE/DISCHARGE CIRCUIT

Sheet 2 of 2

GRUMMAN AEROSPACE CORPORATION

AVOID VERBAL ORDERS

APPENDIX O-1

FROM S. Gaston (signed: S Gaston)	POD	35	9142	DATE 3/22/71
NAME	DEPT. NAME	PLANT NO.	EXT.	NO. D559-1-7

TO: J. Rogers, LM Subcontracts

SUBJECT: GRUMMAN COMMENTS TO THE EAGLE-PICHER SUBMITTED "DVTP 153-2, THERMAL TEST PLAN"

Reference:
a) Contract NAS 9-11074
b) GAC PO #015161
c) EP Test Plan-Part II, Thermal Test Plan, DVTP 153-2, dated 8 March 1971

Enclosure:
1) Revision A to subject test plan per Grumman recommendations.

Please submit Enclosure 1) with the covering comments below to Eagle Picher.

Comments:

"Grumman has completed its review of the preliminary version of DVTP 153-2 (received on 15 March 1971). It was the consensus of the cognizant Grumman engineering personnel that large portions of the plan would benefit from complete revision in the interests of clarifying the objectives of the test, the design and theory of the apparatus, and the detailed test procedures which will be followed.

To this end, the test plan has been rewritten and is hereby submitted to Eagle Picher for review as Enclosure 1).

The subject test plan will be acceptable to Grumman if resubmitted in the form of Enclosure 1).

INFO cc:
J. Benz
V. Iacopelli
D. Lehrfeld
E. Miller
R. Rapp
J. Rogovin/J. Roukis
M. Wertheim
A. Winegard/B. Lijoi
E. Carr, E.P.
J. Cioni, NASA/MSC
F. Ford, NASA/GSFC
G. Foster
J. Janney, NASA/MSC
R. Mallard, E.P.-GAC
C. Waldren, NAVPRO

GAC 977 REV 3
7-68 80M

Maximum Charge Current Limit	=	13.5 amp (*)
Constant Potential	=	1.56 volts
Maximum Cell Pressure Limit	=	100 psig
Third Electrode Resistor	=	27 Ω

NOTES: (*) based on 108% charge return.

D. Test Condition No. 3 - Worst case heat generation using Grumman Development charge regime.

Same conditions as in test condition No. 1, except:

Charge Mode: programmed step modified constant potential

Charge Current 1	- 83.3 amp	1.51 volts
Then Charge Current 2	- 50.0 amp	1.51 volts
Then Charge Current 3	- 20.0 amp	1.51 volts
Then Charge Current 4	- 5.0 amp to end of charge time.	

E. Test Condition No. 4 - Best case heat generation using Grumman Development charge regime.

Same conditions as in test condition No. 2, except

Charge Mode: Programmed step modified constant potential

Charge Current - Same as in test condition No. 3, except maximum cell voltage is 1.56 volts.

NOTE: Preference of order to test runs:

1. Condition No. 1
2. Condition No. 3

10/28/71

From: S. Gaston, Grumman

o: NASA/GSFC

Subject: OUTLINE FOR CALORIMETRIC TESTS FOR CELLS S/N 15 AND 16

Description of cells: S/N 15 baseline design
S/N 16 thin electrode design
Rated capacity = 100 A.H.

A. Conditioning -

Prior to the beginning of cycling at each temperature. the discharged cell shall be shorted across a 0.2 ohm resistor for a period of 16 ±1 hour. The restrained cell shall be brought to a 100% state-of-charge at the respective temperature as follows:

a) $20^{\circ}C$ - Charge at 30.0 amps for 45 hours maximum (or to 1.51 volts) followed by a 10.0 ampere charge for 6 hours (voltage not to exceed 1.51 volts).

b) $0^{\circ}C$ - Charge at 30.0 amperes for 4 hours maximum (or to 1.56 volts) followed by a 10 amp charge for six (6) hours (voltage not to exceed 1.56 volts).

Terminate charge if cell pressure reaches 100 psig.

Orbital cycling to start with cells fully charged. Orbital cycling to start with a discharge.

B. Test Condition No. 1 - Worst case heat generation

Temperature	=	$20^{\circ}C$ (cell temperature)
Depth of Discharge	=	83.3 amp
Discharge Time	=	36 minutes
Charge Time	=	58 minutes
Charge Mode	=	Modified constant potential
Maximum Charge Current Limit	=	62.2 amp (*)
Constant Potential	=	1.51 volts
Maximum Cell Pressure Limit	=	100 psig
Third Electrode Resistor	=	27 Ω

NOTES: (*) based on 120% charge return.

C. Test Condition No. 2 - Best case heat generation

Temperature	=	$0^{\circ}C$
Depth of Discharge	=	12% (12 A.H.)
Discharge Current	=	20.0 amp
Discharge Time	=	36 minutes
Charge Time	=	58 minutes
Charge Mode	=	Modified constant potential

Received

JUN 29

M Worthen

APPENDIX P

ACCEPTANCE TEST PLAN

& SELECTED PERFORMANCE

PROFILES

ATP-251

ACCEPTANCE TEST PLAN
FOR
RSN-110

GRUMMAN AEROSPACE CORPORATION
CONTRACT NO. 0-15161

ITEM 2 - DOCUMENTATION

SUB-ITEM 5.2

AUGUST, 1971

EAGLE-PICHER INDUSTRIES, INC.
ELECTRONICS DIVISION
COUPLES DEPARTMENT
JOPLIN, MISSOURI
64801

William C Harsch
William C. Harsch
Project Engineer

Kenneth Kruger
K. Kruger
Manager, Quality Assurance

1.0 SCOPE

This procedure describes the acceptance tests to be performed on 100 A.H. sealed nickel-cadmium storage cells (E-P RSN-110 Type) produced under P.O. 0-15161 and Prime Contract NAS 9-11074. Tests shall be performed in the order listed on all production cells prior to delivery of the units to GAC.

2.0 REFERENCED DOCUMENTS

2.1 Eagle-Picher

005265	RSN-110 Outline Drawing
EPMP-146	Conditioning Procedure for RSN-110 Cell

2.2 GAC

AD-D5590S-1	Specifications for 100 Ampere-Hour Nickel-Cadmium Storage Cells

Purchase Order 0-15161

3.0 TEST CONDITIONS

3.1 Unless otherwise specified, testing shall be done under laboratory conditions as follows:

A) Temperature: 75± 10°F

B) Barometric Pressure: 30 ± 2 Inches Mercury

C) Relative Humidity: Less than 90%

NOTE: Temperature control shall be maintained by placing cells in a temperature-controlled chamber with circulating air. Cells shall be restrained and separated by aluminum plates of one-half inch nominal thickness. Electrical insulation between cell containers and cans shall be use of sheet of Mylar, Kapton or equivalent material. Cell clamping shall be by means of six (6) bolts or lengths of threaded rod (1/4") with nuts torqued to 5-6 inch pounds.

A typical group consists of 10-14 restrained cells. Temperature of the chamber shall be monitored and periodically recorded.

3.2 Accuracy of Test Equipment

3.2.1 Temperature ± 0.5°F

3.2.2 Visually Read Ammeters ± 0.5% full scale (With anti-parallox scales)

3.2.3 Visually Read Voltmeters ± 0.5% full scale

3.2.4 Panel meters or meters of less accuracy shall be used as "indicator only".

3.2.5 Digital recorded Voltage X.XXX

3.3 Equivalence

For purposes of this document, equivalence shall be taken to mean the ability to duplicate the function of listed equipment including specified accuracy where applicable. Listed test equipment is for reference only.

4.0 TESTING

4.1 Preparation

Verify that cells have been activated and tested per the requirements of EP-MP-146.

4.2 Temperature Stabilization

Temperature stabilization shall be attained when three consecutive readings taken 15 minutes minimum apart are within the test temperature and vary no more than two degrees Fahrenheit.

4.3 Maximum Charge Voltage

Cell voltage on charge at 20°C (68 ±5°F) shall not be allowed to exceed 1.510 volts.

Charge voltage at 0°C (32 ±5°F) shall not be allowed to exceed 1.560 volts.

4.4 Maximum Pressure Limit

Cells shall not be allowed to exceed 100 psig during charging at any temperature or rate.

4.5 Temperature Monitor

As a minimum, a thermocouple shall be located near the center of a broad face of a cell in each formation group. The junction and bare wire must be insulated from the cell case and restraining plate by a layer of électrical insulating tape. Provisions for thermocouple leads may be made by cutting a narrow slot in the insulating shim.

Preferably, cells may be restrained individually and one (1) restraining plate for each cell slotted to accomodate the thermocouple.

4.6 Equipment Required

Item	Mfg.	Model
DC Power Supply	Harrison Lab	6268A or Equal
Ammeter	Weston	931
Ammeter	Weston	1
Shunts (100 Amp)	Weston	
Potentiometer Pyrometer	Thermo-Electric	70200
Temperature Chamber	Missimers	-100x350
Digital Data Acquisition System Tape Printout and Tape Punch Output	NLS	

4.7 Test Sequence

Table No. I indicates the test sequence for acceptance testing of 100 ampere cells for GAC.

TABLE NUMBER I

1. Conditioning Cycle

   a) Charge 10 amps for 16 hours

   b) Discharge 50 amps to 1.0 volts

   c) Drain across 0.2 ohm for 8 hours minimum

   d) Dead short one (1) hour minimum

2. Three (3) full capacity cycles at 0°C.

3. Three (3) orbiting cycles at nominal orbiting regime at 0°C.

4. Overcharge: 5 ampere for 8 hours @ 0°C

5. Three (3) full capacity cycles at nominal orbiting regime @ 20°C

6. Three (3) orbiting cycles at nominal orbiting regime @20°C

7. Overcharge: (10 amps for 8 hours @20°C)

8. Phenolphthalein Leak Test

4.8 <u>Test Procedure</u>

4.8.1 Conditioning (Test 1)

4.8.1.1 Assure that cells have been shorted across a 0.2 ohm resistor for 16 hours minimum prior to this test.

4.8.1.2 <u>Charge</u>

Connect cells to a power supply and charge at 10 amperes for 16 hours. If an individual cell reaches 1.510 volts or cell pressure reaches 100 psig prior to sixteen hours charge, place the cell on open circuit by activating the corresponding switch on the switch panel. Note and record the duration of charge for each cell.

4.8.1.3 Discharge

At termination of charge for all cells, turn off and disconnect the power supply and conduct a 50 ampere discharge. Note and record the time for each cell to reach 1.000 volt and remove from the circuit at 0.9 ± 0.1 volt.

4.8.2 Capacity Determination (Test 2)

4.8.2.1 Stabilize cell temperature at 32 ± 5°F per paragraph 4.2 above.

4.8.2.2 Connect cell group to D.C. power supply and charge at 30 amps for 4.5 hours. If a cell voltage reaches 1.560 volts or if cell pressure reaches 100 psig, remove that cell from charge. Note and record the charge accepted by each cell.

4.8.2.3 Conduct discharge at 50 amperes

4.8.2.3.1 Note and record time for each cell to reach 1.000 volt

4.8.2.3.2 Remove each cell from circuit at a voltage of 0.9 ± 0.1 volt per cell

4.8.2.4 Repeat steps 4.8.2.2 and 4.8.2.3 additional two (2) times for a total of three (3) cycles.

4.8.3 Cycle - 30% DOD (Test 3)

4.8.3.1 Stabilize cell temperature at 32 ±5°F per paragraph 4.2.

4.8.3.2 Verify that cycle panel is adjusted to 58 min. charges and 36 minutes discharge.

4.8.3.3 Connect cells to power supply and charge cells at 30 amperes for 4.5 hours with the usual voltage and pressure constraints.

4.8.3.4 Connect cell group to cycle panel and begin cycling (discharge at 50 amperes and charge at 34.2 amps). Conduct three (3) cycles.

4.8.3,5 Conduct discharge per paragraph 4.8.2.3.

4.8.4 <u>Overcharge (Test 4)</u>

4.8.4.1 Stabilize cell temperature per paragraph 4.2

4.8.4.2 Charge cells at 30 amperes for 4.5 hours, observing voltage and pressure limitations.

4.8.4.3 Lower charge rate to 5 amps and continue charge for an additional eight (8) hours, observing voltage and pressure limits.

4.8.4.4 Note and record total charge accepted by each cell.

4.8.4.5 Discharge cell group at 50 amperes as in 4.8.2.3.

4.8.5 <u>Capacity - 68± 5°F (Test 5)</u>

4.8.5.1 Verify stabilization per paragraph 4.2

4.8.5.2 Charge cells at 30 amps for 5 hours, observing 1.510 voltage limit and 100 psig pressure limit.

4.8.5.3 Conduct standard fifty (50) ampere discharge as per paragraph 4.8.2.3.

4.8.5.4 Repeat paragraph 4.8.5.1-4.8.5.3 for a total of three (3) capacity cycles.

4.8.6 <u>Cycle (30% DOD) - Test 6</u>

4.8.6.1 Verify temperature stabilization at 68 ± 5-F

4.8.6.2 Charge cell group at 30 amperes for five hours. observing 1.510 voltage limit and 100 psig pressure limit.

4.8.6.3 Verify that cycle is set for 36 minutes discharge and 58 minutes charge.

4.8.6.4 Connect cells to test panel and begin cycling. (Discharge at 50 amperes and charge at 37.4 amperes) Subject cells to three discharge-charge cycles.

4.8.6.5 Discharge cells as in paragraph 4.8.2.3.

4.8.7 <u>Overcharge @20°C (Test 7)</u>

4.8.7.1 Verify temperature stabilization

4.8.7.2 Charge cells at 30 amps for 5 hours. If any cell voltage reaches 1.510 volts or pressure exceeds 100 psig, remove that cell from the circuit.

4.8.7.3 Reduce rate to ten (10) amps and continue charge for an additional eight (8) hours.

4.8.7.4 Conduct electrolyte leak test per GAC Spec. 4.5.13 Electrolyte Leakage.

4.8.7.5 Conduct discharge as in Paragraph 4.8.2.3.

4.8.8 <u>Impedance Test - TBD</u>

4.8.9 <u>Capacity Discharge (20°C) - Test 9</u>

4.8.9.1 verify temperature stabilization

4.8.9.2 Charge cells at 30 amps for 5 hours. If any cell voltage exceeds 1.510 volts or pressure exceeds 100 psig, remove that cell from the circuit.

4.8.9.3 Conduct discharge at 50 amperes to 0.5 volt minimum. Record time for each cell to 0.5 volt (to the nearest minute).

4.8.10 <u>Cell Drain</u>

4.8.10.1 Connect a nominal 0.2 Ω resistor across the terminals of each cell for sixteen (16) $^{+1}_{-0}$ hours.

4.8.10.2 Remove resistor and allow cell to remain on open circuit for a period of 24 ± 0.5 hours.

4.8.10.3 Record voltage for each cell. A cell display-ing a voltage less than 1.150 shall be rejected.

4.9 Data Acquisition

4.9.1 Reference Electrode

27 ohm, one half watt resistors shall be connected between each cell auxiliary electrode and the respective cell negative electrode. The potential across each resistor shall be monitored by the two hundred channel data acquisition system.

4.9.2 Current

Current shall be measured by monitoring voltage across a shunt. Additionally, current shall be monitored by a D.C. ammeter.

4.9.3 Frequency of Recordings

4.9.3.1 Full Capacity Tests

4.9.3.1.1 Punched Tape

Open circuit readings shall be taken before and after all charges and discharges. Charge readings (all channels monitored) shall be taken after one (1) minute on test and at 15 minute intervals except during overnight charging periods. It is desired to have one (1) hour readings during overnight low rate charges. Discharge values (all channels monitored) shall be taken after one (1) minute and at 15 minute intervals.

4.9.4.1.2 Tape Printout and Hand Recording

Tape printout shall be at intervals of 30 minutes on charge and 15 minutes on discharge, in addition to open circuit voltages and one minute voltages. Voltages shall be recorded for each cell and its auxiliary electrode. Pressure readings shall be taken at 30 minute intervals except during overnight charging periods. Temperature measurement shall be recorded for a control cell and the temperature chamber. Temperature readings shall be taken each 30 minutes except during overnight charging periods. Hand recording may consist of transferral of printed data to data sheets.

4.9.4.2 Cycle Testing

See appropriate data sheet

4.10 Identification and Inspection

Each cell shall be examined to assure compliance with Eagle- Picher Cell Outline Drawing No. 005265 and applicable GAC Drawings. Each completed and tested cell shall be inspected with respect to good workmanship, construction, sealing of cell container, weight, dimensions, identification marking, packaging and packing.

Measure cell thickness at each of the four (4) corners and center when cell is placed on a flat surface.

Supply individual weight and dimensional data to GAC.

5.0 QUALITY ASSURANCE AND TEST WITNESSING

a) Eagle-Picher engineering personnel shall advise Eagle-Picher Quality Assurance of development schedules so they may audit tests and data as required.

b) Eagle-Picher shall continuously advise Grumman Aerospace Corp. of current test schedules in order that Grumman quality assurance and/or engineering personnel may witness any of the testing.

c) Eagle-Picher shall also advise resident DCAS personnel of test schedules in order that they may review progress of any of the tests.

d) Rejection Criteria

1. Capacity - Any cell which cannot meet a minimum capacity of 95 ampere-hours at 0°C and 100 ampere-hours at 20°C for all discharges to 1.0 volts per Paragraphs 4.8.2 and 4.8.5 shall be rejected.

2. Discharge Voltage - Any cell which exhibits a discharge plateau voltage, or a cell voltage after removal of 50 ampere-hours, of less than 1.15 volts during all 50 ampere discharges specified herein shall be rejected.

3. Excess Currents - Any cell which had received currents, either charge or discharge, at any time in excess of 100 amperes, or was overdischarged (below 0.0 volts) shall be rejected.

4. Over Temperature - Any cell which has been exposed to temperatures in excess of +120°F during any period prior, during or after the application of the tests specified herein shall be rejected.
5. High Internal Resistance Check - Any cell which cannot meet the open circuit voltage recovery check per Paragraph 4.8.10 shall be rejected (one additional repeat test of Paragraph 4.8.10 after an additional cycle per Paragraph 4.8.9 is permissable on cells failing to meet this requirement).
6. Electrolyte Leakage - Any cell which fails to meet the electrolyte leak test of Paragraph 4.8.7.4 shall be rejected.
7. Visual - Any cell which fails to meet good workmanship, identification marking, excess dimensions per Drawing 005265 requirements shall be rejected.

GRUMMAN AEROSPACE CORPORATION

AVOID VERBAL ORDERS

APPENDIX P

P-1

MW

FROM					DATE 6/29/72
	M. Wertheim	553/POD	35	9142	
	NAME	GROUP NO. & NAME	PLANT NO.	EXT.	NO. D559-2-28

TO:

J. Rogers
W. Harsch/E. Carr

SUBJECT: APPROVAL OF ACCEPTANCE TEST PLAN, EAGLE-PICHER NO. ATP-251, DATED AUGUST 1971, RECEIVED AT GRUMMAN JUNE 29, 1972

Reference: a) Contract no. NAS 9-11074
b) Grumman PO No. 0-15161

Attachment: Eagle Picher Acceptance Test Plan for RSN-110, ATP-251

Approval is hereby granted for the subject acceptance test plan, ATP-251, in the form shown attached. Eagle-Picher is authorized to use this plan for acceptance tests for all cells starting with the current build.

S. J. Gaston/MW

S. J. Gaston, Project Engineer

INFO cc:

J. Cioni
F. Ford
T. Hine
R. Mallard
E. Miller
S. Orehosky
R. Sablich
W. Thomas
R. Wannamaker

GAC 377 REV. 4 [redacted]

APPENDIX P-2

VOLTAGE, PRESSURE & AUXILIARY ELECTRODE SIGNAL PROFILE CURVES FOR 3 ORBITAL CYCLES AT 20°C & 0°C

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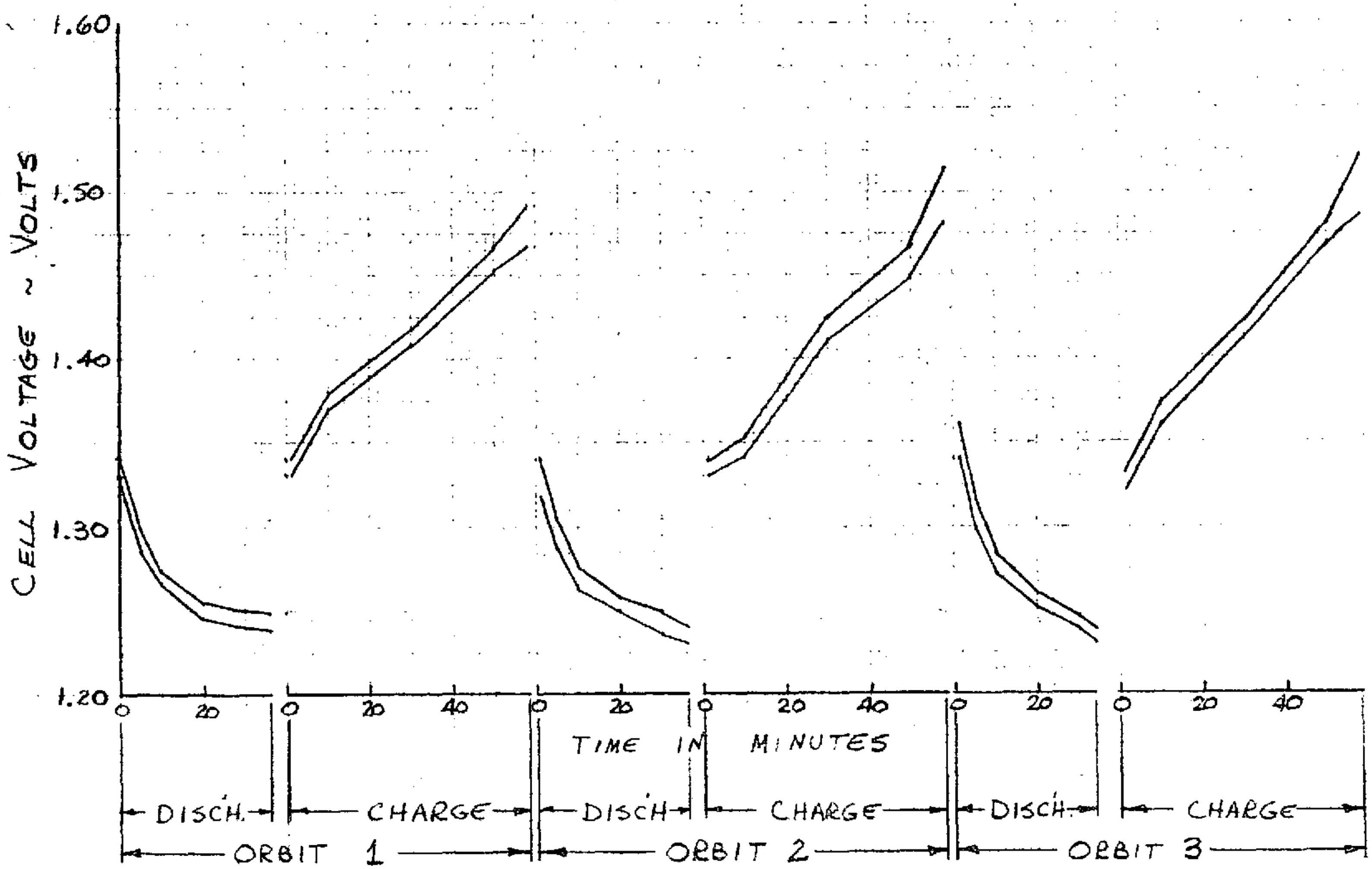
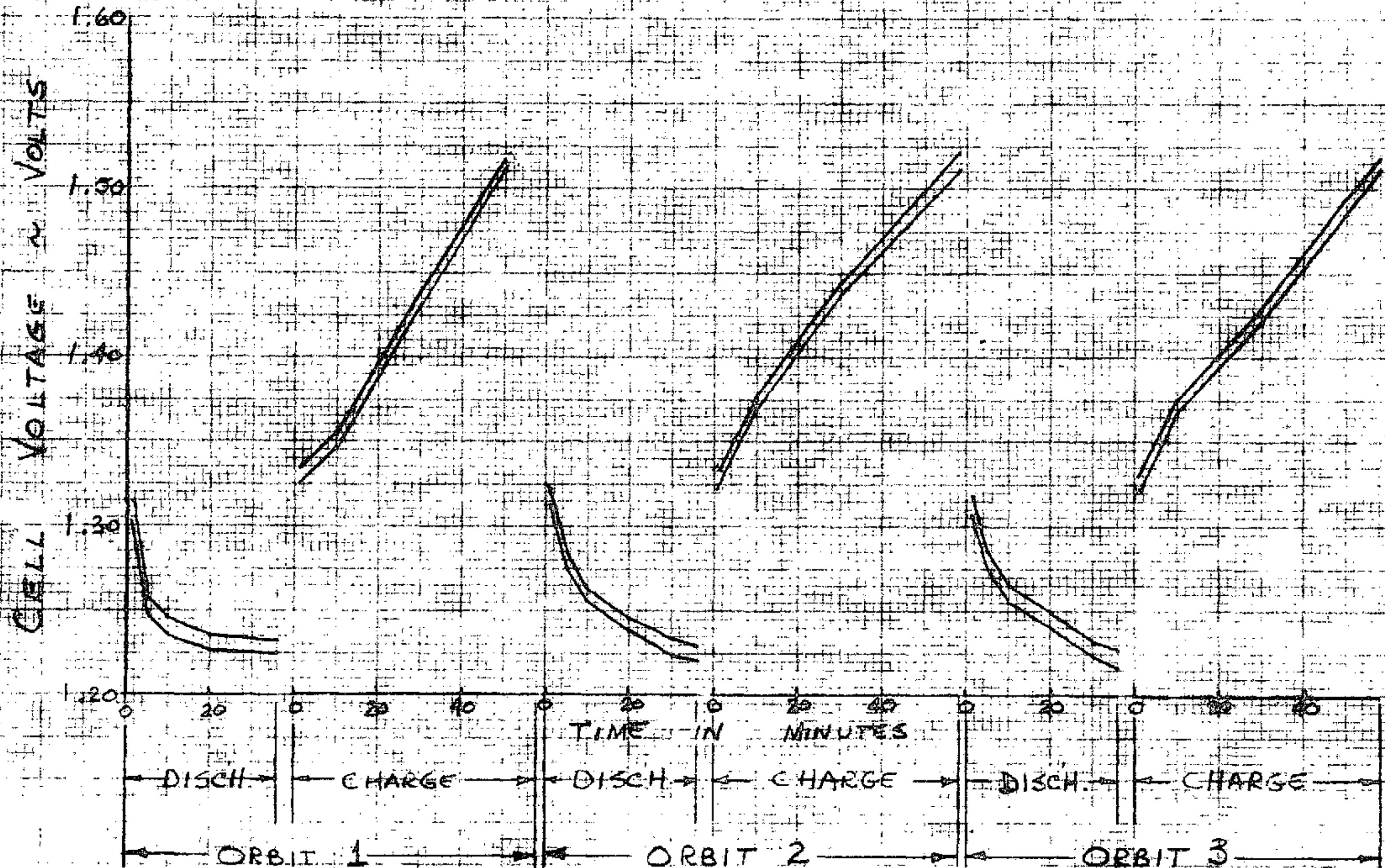
PARAMETRIC CELL GROUP I (P2505W THIN PLATE)
ACCEPTANCE TEST DATA AT EAGLE-PICHER
3 ORBITAL CYCLES - 20°C
CELL VOLTAGE



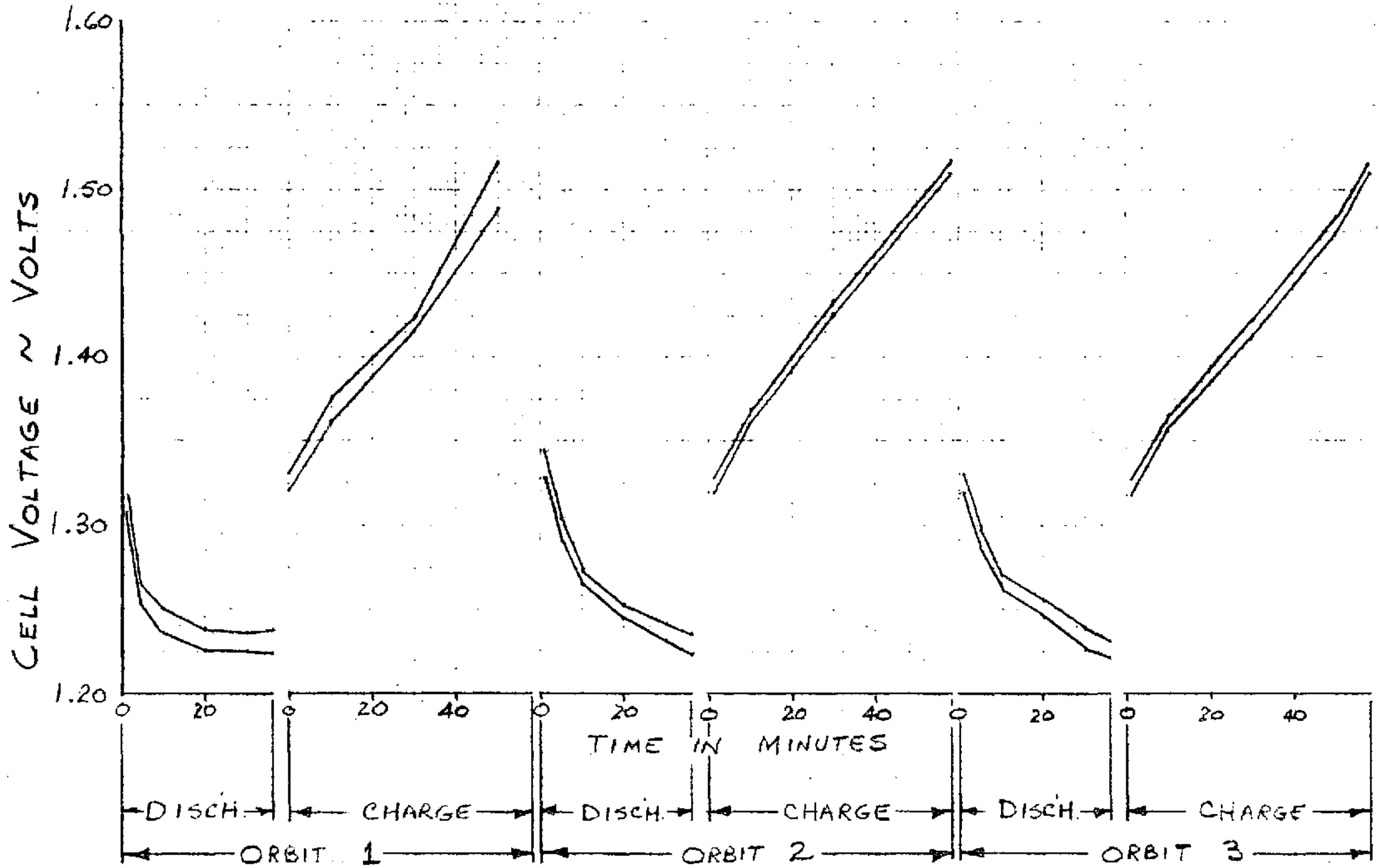
APPENDIX P-2 FIGURE 1

PARAMETRIC CELL GROUP II (WEx 1242W THIN PLATE)
ACCEPTANCE TEST DATA AT EAGLE-PICHER
3 ORBITAL CYCLES - 20°C
CELL VOLTAGE



APPENDIX D-2 FIGURE 2

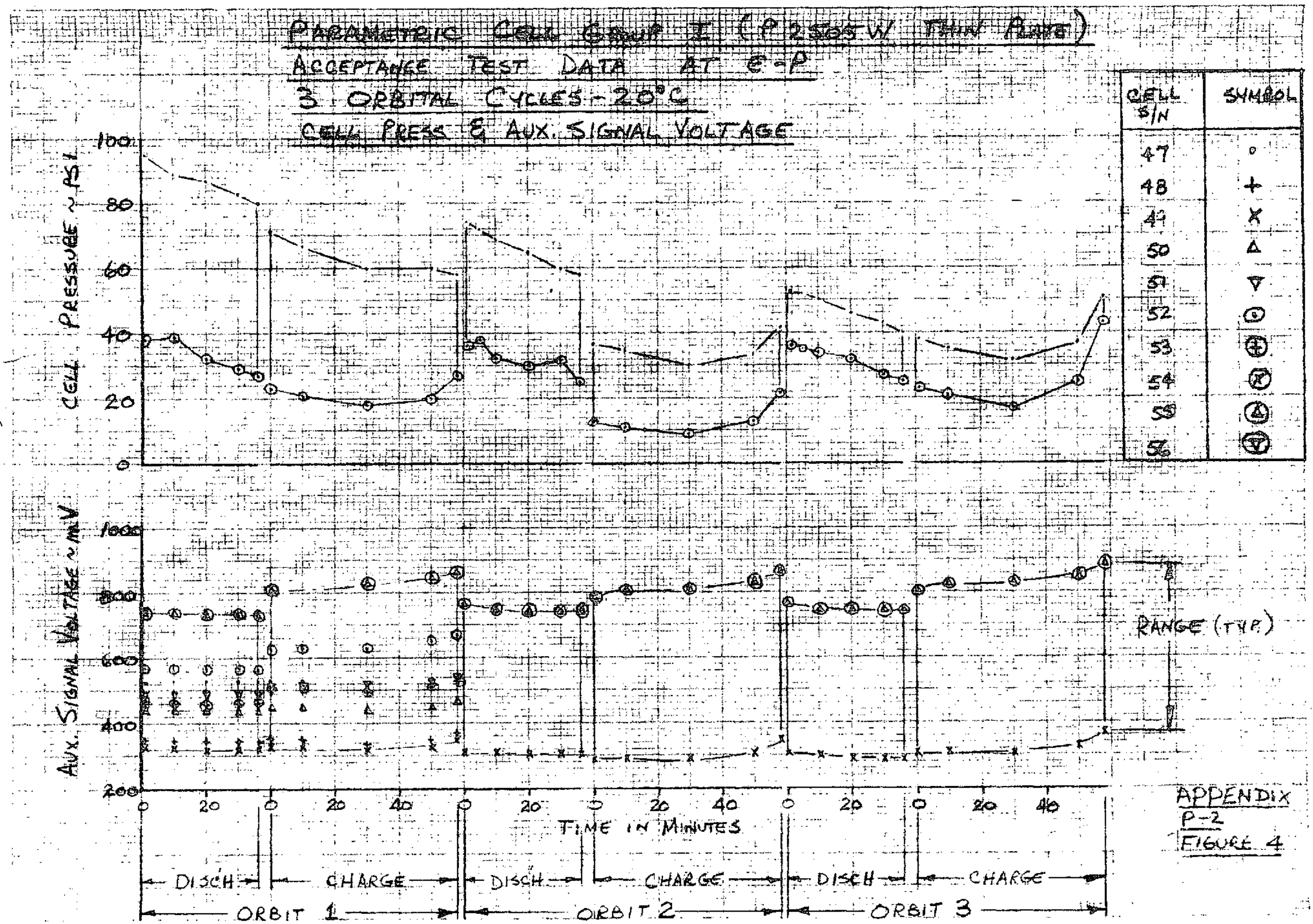
PARAMETRIC CELL GROUP III (P2505W BASELINE PLATE)
ACCEPTANCE TEST DATA AT EAGLE-PICHER
3 ORBITAL CYCLES – 20°C
CELL VOLTAGE



APPENDIX P-2 FIGURE 3

C-3

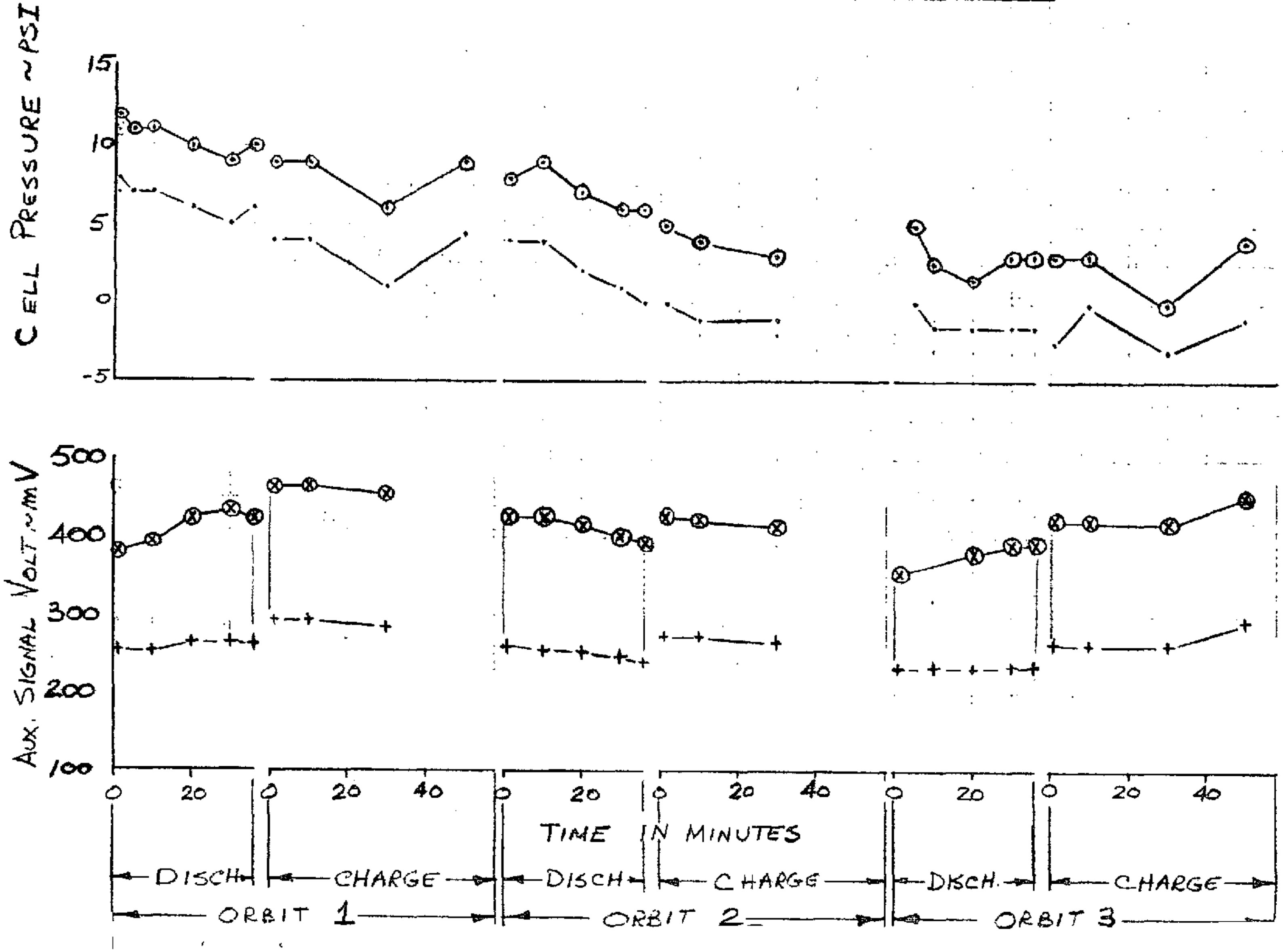
GRP II
2
Cell Press & Aux Volt



APPENDIX
P-2
FIGURE 4

565

PARAMETRIC CELL GROUP II (WEX 1242W THIN PLATE)
ACCEPTANCE TEST DATA AT E-P
3 ORBITAL CYCLES -20°C
CELL PRESSURE & AUX. SIGNAL VOLTAGE

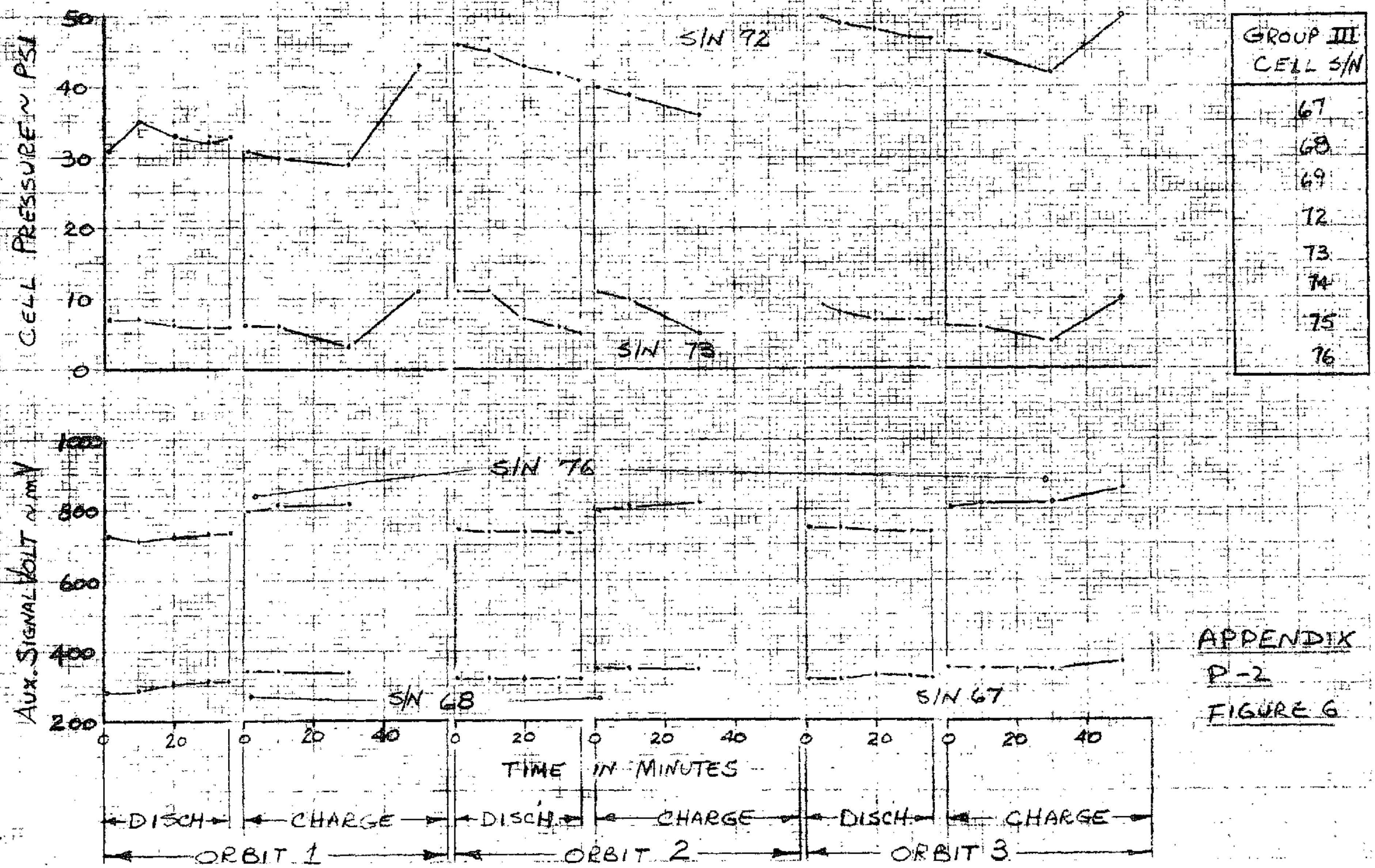


CELL S/N	SYMB
57	•
58	+
59	×
60	Δ
61	∇
62	⊙
64	⊕
65	⊗

APPENDIX P-2
FIGURE 5

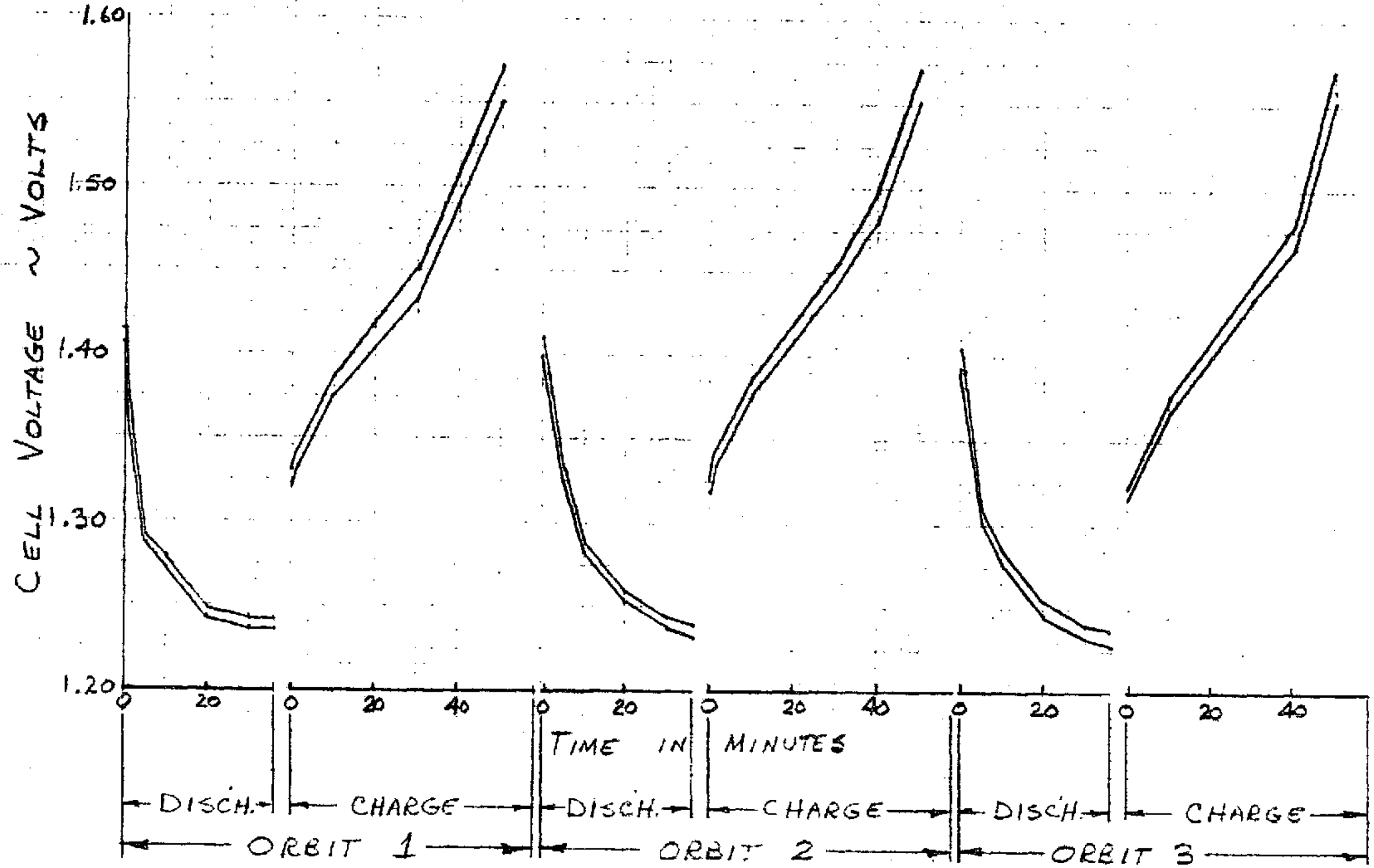
GRP III

PARAMETRIC CELL GROUP III (P 2505W BASELINE PLATE)
ACCEPTANCE TEST DATA AT G-P
3 ORBITAL CYCLES - 20°C - CELL PRESSURE & AUX SIGNAL VOLTAGE



APPENDIX P-2
FIGURE 6

PARAMETRIC CELL GROUP I (P 2505 W THIN PLATE)
ACCEPTANCE TEST DATA AT EAGLE-PICHER
3 ORBITAL CYCLES - 0°C
CELL VOLTAGE

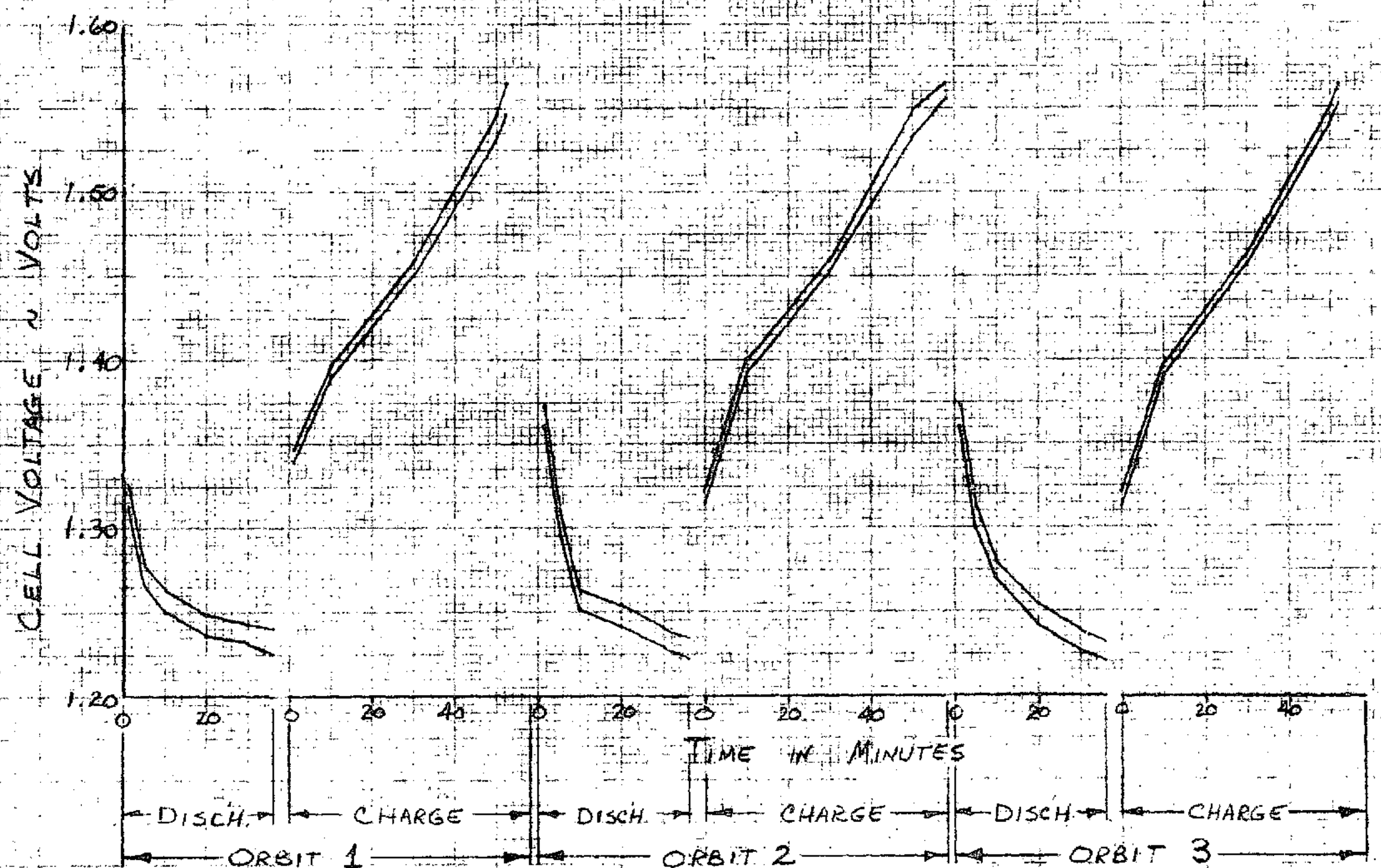


APPENDIX
P-2
FIGURE 7

GRP II

0°

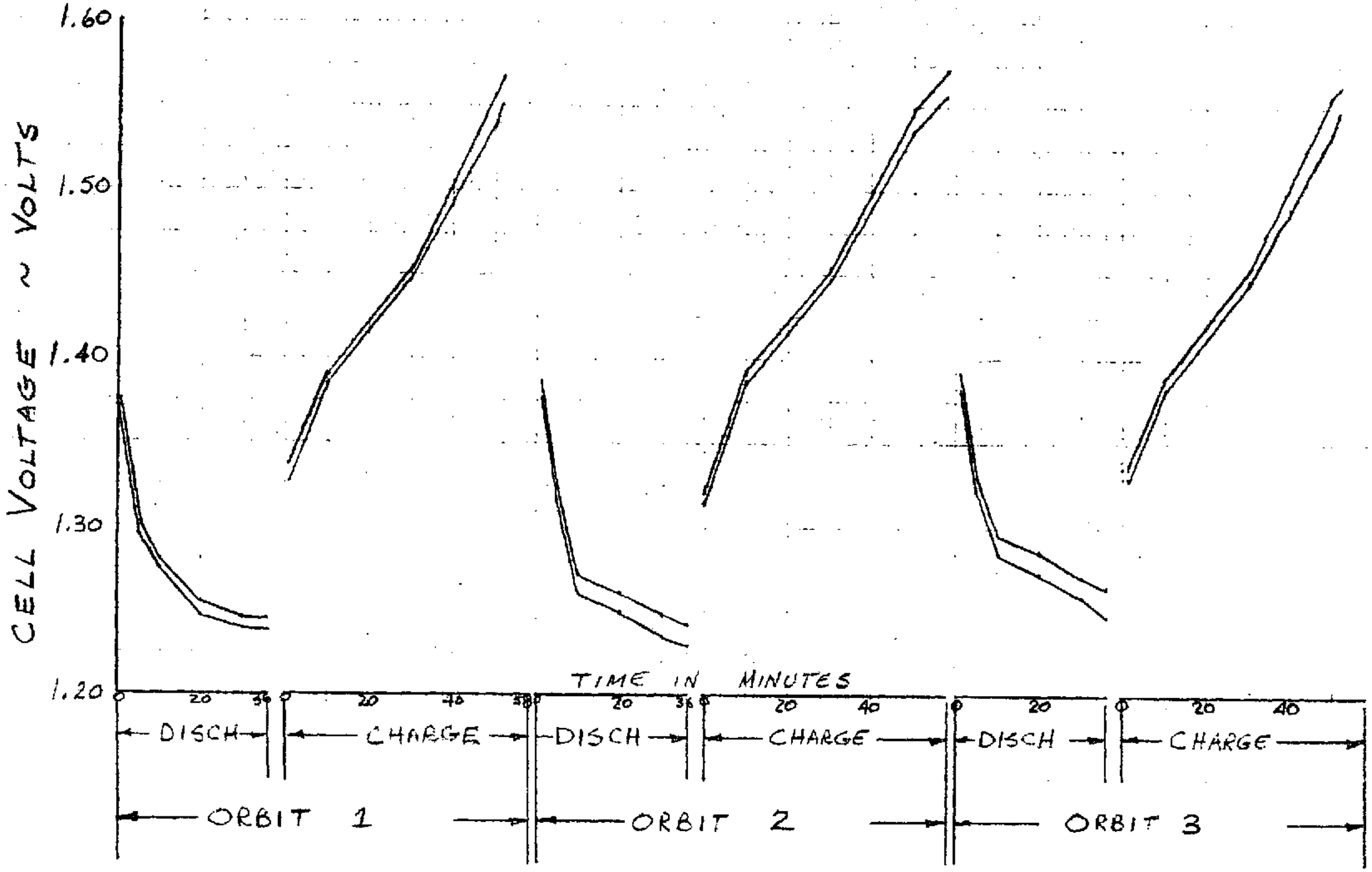
PARAMETRIC CELL GROUP II (WEX 1242W THIN PLATE)
ACCEPTANCE TEST DATA AT EAGLE-PICHER
3 ORBITAL CYCLES - 0°C
CELL VOLTAGE



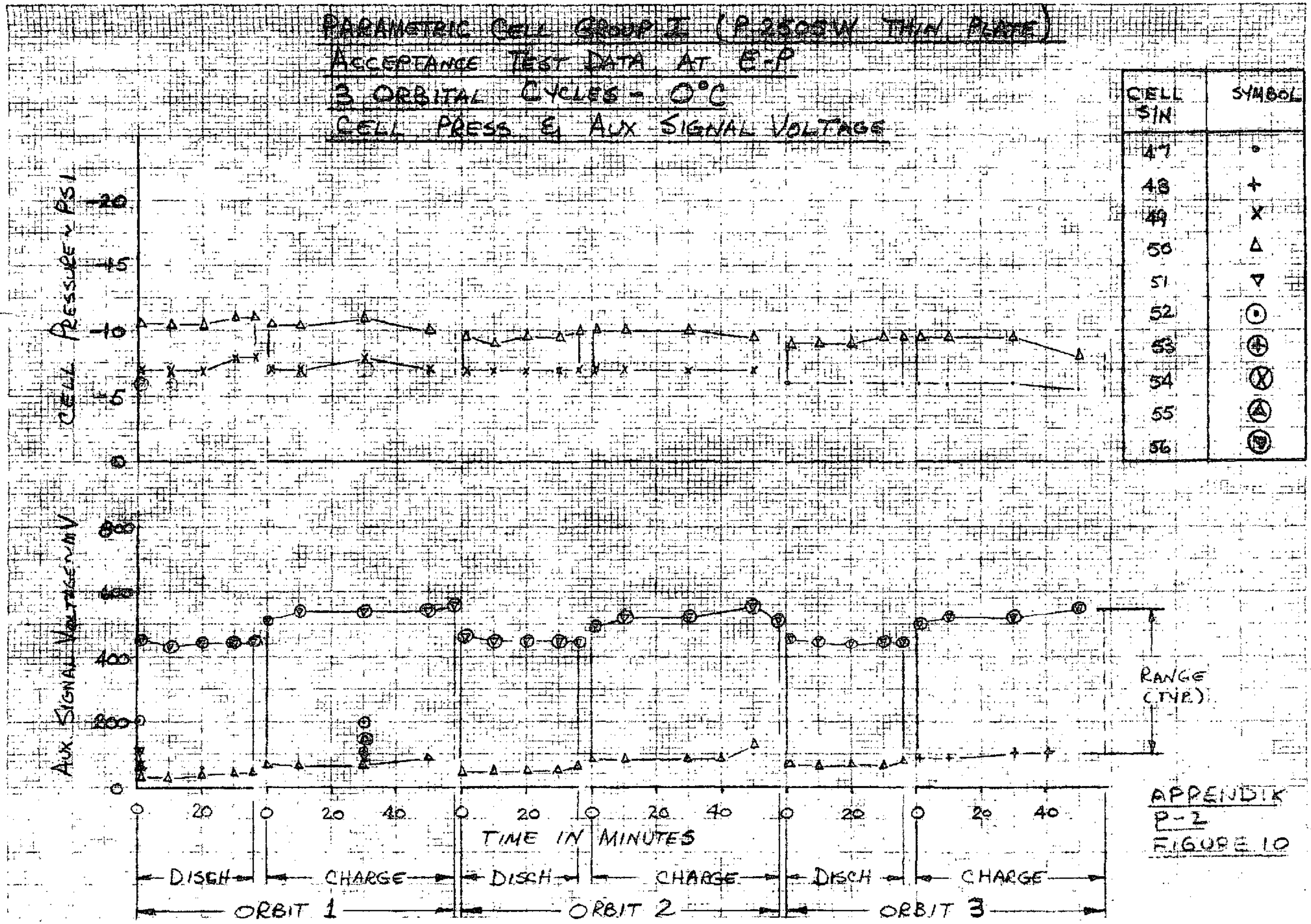
APPENDIX F-7
FIGURE B

569

PARAMETRIC CELL GROUP III (P2505W BASELINE PLATE)
ACCEPTANCE TEST DATA AT E.P.
3 ORBITAL CYCLES - 0°C
CELL VOLTAGE



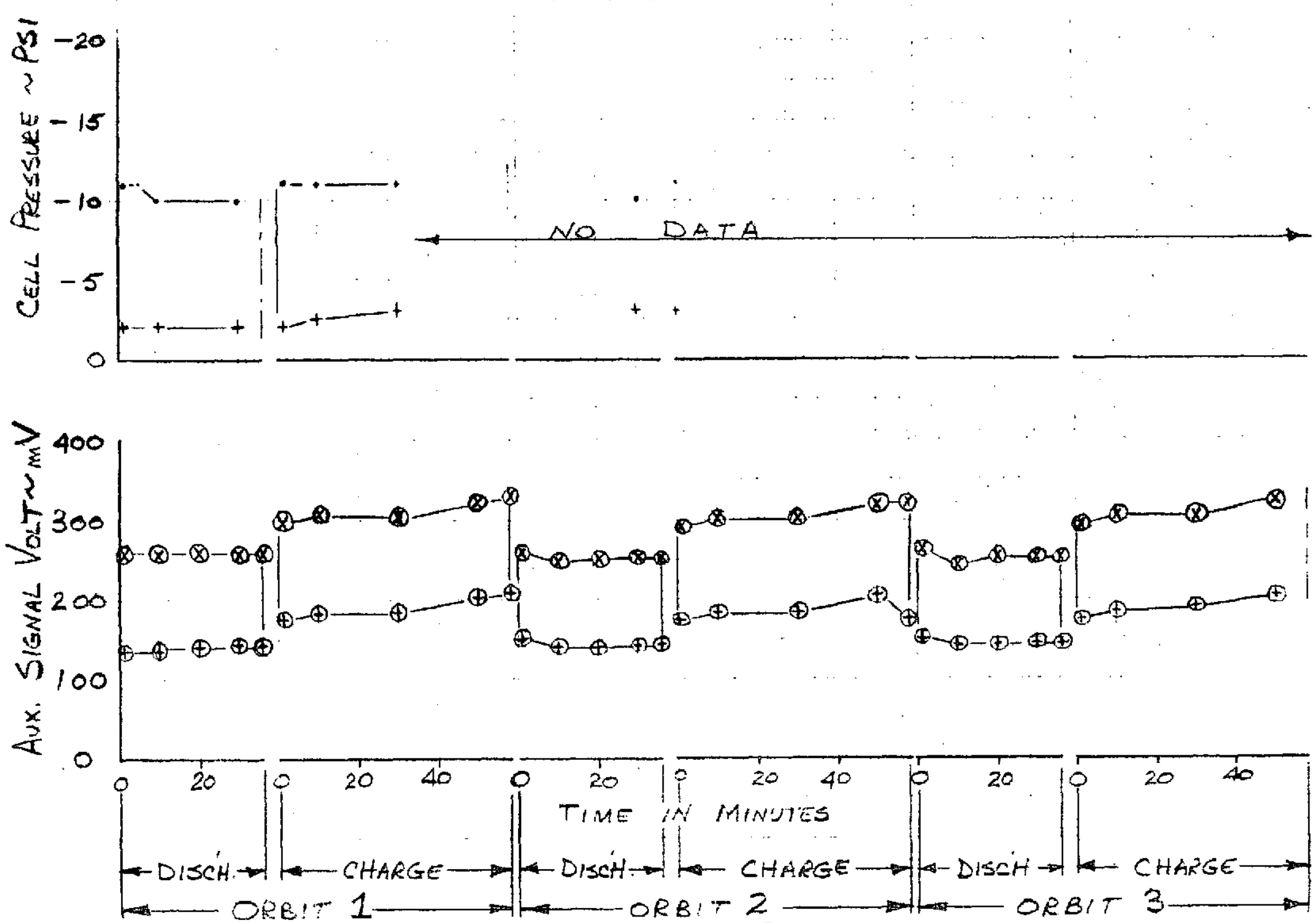
APPENDIX D-2 FIGURE 9



APPENDIX P-2
FIGURE 10

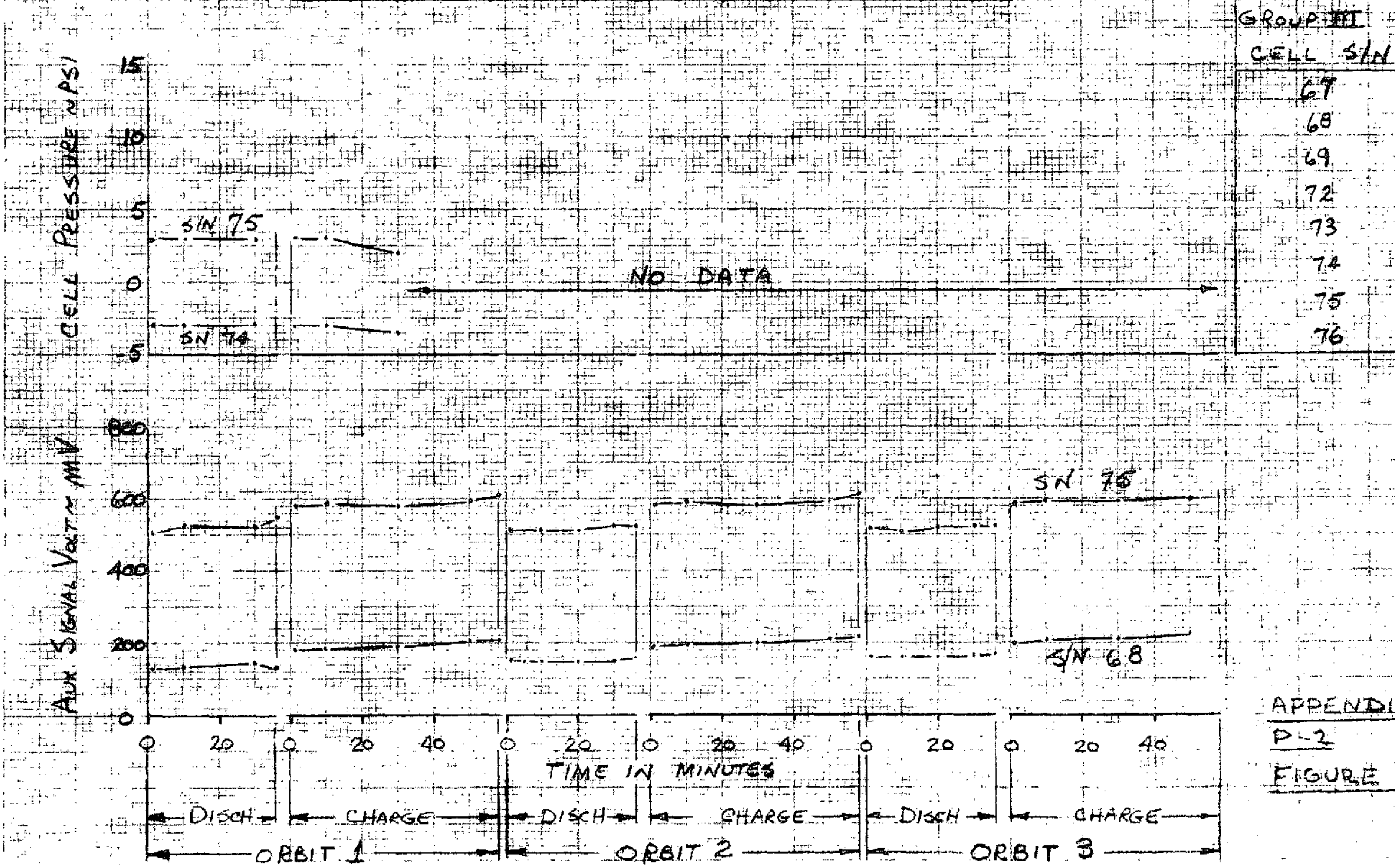
PARAMETRIC CELL GROUP II (WEX 1242W THIN PLATE)
ACCEPTANCE TEST DATA AT E-P
3 ORBITAL CYCLES - 0°C
CELL PRESSURE & AUX SIGNAL VOLTAGE

CELL S/N	SYMBOL
57	•
58	+
59	×
60	Δ
61	∇
62	⊙
64	⊕
65	⊗



APPENDIX P-2
FIGURE 11

PARAMETRIC CELL GROUP III (P2505W BASELINE PLATE)
ACCEPTANCE TEST DATA AT G-P
3 ORBITAL CYCLES - 0°C
CELL PRESSURE & AUX SIGNAL VOLTAGE



APPENDIX
P-2
FIGURE 12

TEST CONTROLLER (RACK) OPERATION

1. General

There are two separate and distinct functional controls in each test controller (rack) as follows:

1. Charge/Discharge Control.
2. Orbit Timing and Mode Transfer Control. The two controls are interactive in that the latter informs and controls the former in charge and/or discharge mode, and driving transfer.

2. Charge/Discharge Control

Figure 1 is a block diagram of this control. The following is a description of its operation:

a) During discharge the DOD Sub-bound in Board 3 determines the current level at which the Power Supply shall operate when connected in series aiding with the String Under Test (S.U.T.) and an appropriate load resistor (0.240 for 12%--20 AMP for 30% DOD-- 50 AMP; 0.060 for 50% DOD-- 83 AMP). This is accomplished as follows:

APPENDIX Q

BATTERY/CELL TEST

CONTROLLER DESIGN

& OPERATION

1. The DOD level of the Programmable Reference. The current flow is sensed in the shunt, and the resultant millivolt drop is amplified and then compared to the reference level.
2. The error is amplified and buffered in a special "floating" output circuit which then drives TB2-7 and TB2-8 of the Power Supply-- the current programming terminals. It can be seen that this is a closed loop system. Acutally, since the Power Supply has its own current control loop, our system constitutes a loop within a loop. It should be noted, the only reason for closed loop operation in our system is to provide for the tolerance errors required by the current loops of each Power Supply.

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2. Charge/Discharge Control (Cont'd.)

b) During charge, other elements of the DOD Sub-board, and the Main part of Board 3 determine the current level at which the power supply shall charge the S.U.T. The charge ratio is programmable as a function of a Temperature Modified Voltage Limit (of the S.U.T. Operation is as follows:

1. Each current level is controlled as described in (a) above.
2. The reference level to set the current level is determined by the state of Current Programming Logic in board two. The logic is basically a filled storage register which acquires a "bit" of information the first time the Analog Switch of Board 2 changes state. The second and third times the register acquires its 2nd and 3rd bits respectively, and is thereafter filled. Each bit causes one element of the Programmable Referece (there are four altogether) to become shorted, removing its contribution from a summing circuit. Thus, with no bits in the register, charge rate is maximum; while with the register filled, charge rate is minimum. Charge rates are:
   - 83 Amps
   - 50 Amps
   - 20 Amps
   - 5 Amps (Trickle)
3. The Analog Switch is triggered by comparing a mixed signal directly to the S.U.T voltage and inversely proportional to the S.U.T temperature, with the output of a Switchabel Reference. The switchabel Reference provides the capability to alter the location of the resultant negative-temperature coefficient voltage/temperature line as follows (volts/cell limit);

	Level 1	Level 2	Level 3
$0^{o}C$	1.53 V	1.56 V	1.59 V
$20^{o}C$	1.48 V	1.51 V	1.54 V

Level 1 occurs with both switches "up"; level 2 with the top switch down, the bottom switch "up"; level 3 with both switches "down".

4. The Voltage/Temperature Detector is so constructed that the two signals are received separately, processed and mixed. Thus the number of cell in the S.U.T. and the reference setting do not affect the linearity of the voltage/temperature line.

c) During transfer from charge to discharge mode and vice versa, the Orbit Timing and Mode Transfer Control issues the following commands to the Charge/Discharge Control:

1) Before the main power contractors transfer, Stop Charge (or Stop Discharge) command is issued to insure low current make and break.

2) After the new mode is established, Start Charge (or Start Discharge) command is issued.

3) The Stop Charge command fills the Current Program Logic register, causing the charge ratio to go to minimum.

4) The Start Charge command empties the register, permitting maximum charge rate.

5) The Stop Discharge command shorts the discharge reference causing minimum discharge current.

6) The Start Discharge command opens the reference to the value set by the DOD Sub-board, allowing normal current.

7) The Charge/Discharge command is a pair of contact closures (interlocked) which connect the desired reference to the error amplifiers in the current control loop.

2. c) (Cont'd.)

8) The Zero Voltage Program and Zero Current Program commands short the Power Supply voltage control loop (to insure supply output voltage is zero) and the Current Control Signal from the "floating" output circuit (to insure supply output current is zero) during each transfer. It is important to note that this is a momentary function which begins with initiation of transfer, and lasts until after the appropriate Start command is issued. The Power Supply is thus under full control at all times, enhancing reliability.

3. Orbit Timing and Mode Transfer Control

Figure 2 is a block diagram of this control. The following is a description of its operation:

1) Orbital Timing is accomplished through the Binary Counter and Coincidence Gates. At 40 seconds after each minute, the Data Acquisition System outputs a pulse. This is shaped and amplified in the Timing Amplifier, and applied to the Binary Counter "clock" line. The Binary Counter output drives thru (3) Coincidence Gates as follows:

- Discharge Gate outputs logic "1" at count 1
- Charge Gate outputs logic "1" at count 37
- Counter Reset Gate outputs logic "1" at count 94

This provides a discharge period of 36 minutes, and a charge period of 58 minutes (a total orbital simulation of 94 minutes). The Discharge Coincidence (logic "1") and Charge Coincidence signals are each fed to both the Contractor Controller/Fault Protection and Mode Controller boards in their turn. The Counter Reset Coincidence signal is returned to the Binary Counter, resetting the counter to zero.

3. Orbit Timing and Mode Transfer Control (Con'td.)

1) Continued

Reset signals to the counter are also available through the Contactor Controller/Fault Protection board (used to synchronize several Test Controllers simultaneously), and by the center pushbutton switch at the outer edge of the Binary Counter and Coincidence Gates board. When timing is not being used, or if it is to be defeated (such as during Test Controller testing), artificial coincidence signals may be developed by using the upper (charge) and lower (discharge) pushbutton on the edge of this board. Finally the Charge Coincidence is fed to Progammmable Reference of board 3 as the Stop Discharge signal; and the Discharge Coincidence is fed to the Current Programmer Logic of board 2 as the Stop Charge Signal.

2) The Contactor Controller provides:

- A series of delays (millisecond) so the power contactors switch on low current.
- The discharge/charge current reference connects to the Programmable Reference of board 3.
- The Binary Counter reset signal for initiation.
- Steering for the power contactors in the Mode Controller
- Start Charge and Start Discharge signals to boards 2 and 3 respectively after mode is established.
- Start Charge and Start Discharge signals to the Mode Controller. Each of these functions is described in detail in the Board 5/6 writeup. The green lamp signifies that charge mode is established. The amber that discharge mode is established.

3. Orbit Timing and Mode Transfer Control (Cont'd.)

3) The Fault Protection provides interruption of either charge or discharge mode, including disconnection of the Power Supply from the S.U.T., for the following conditions:

- Loss of any bias voltage (power fault)
- Cell under/over voltage (cell fault)
- Excess cell pressure (all fault)

Either type of fault causes the mode lights to go out, and the red fault light to turn on. Power fault maybe reset (i.e. the rack may be returned to operating mode) by using the red pushbutton on the inside front surface of this board. (This must be doen also when the rack is first energized). Cell faults may be reset by using the black pushbutton immediately below the light bank on the front edge of this board. Cell faults will occur when any cell in the S.U.T. being controlled by a particular rack reaches the following limits:

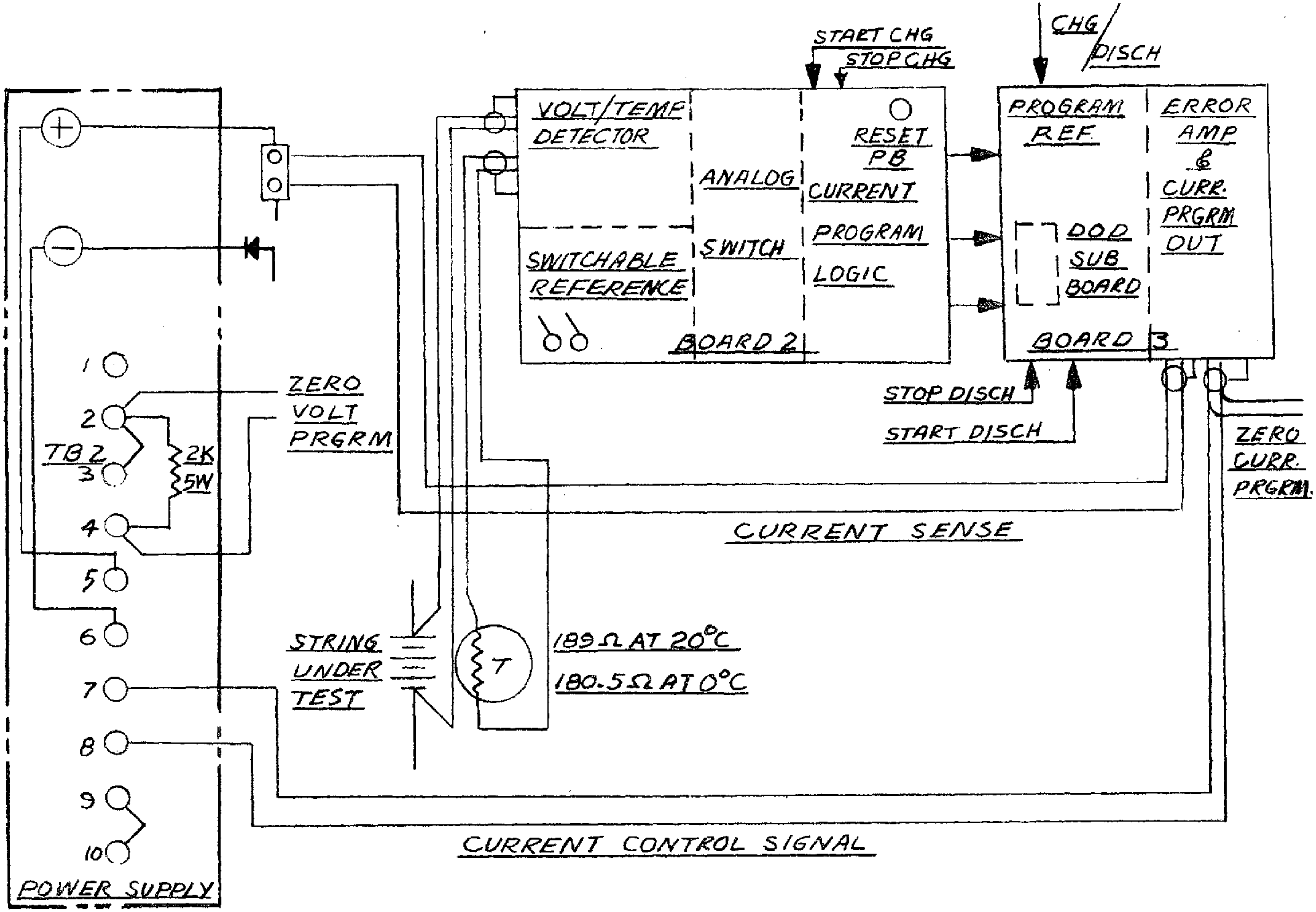
- Overvoltage-------- 1.65V
- Undervoltage------- 1.05V
- Overpressure------- 85 PSIG

Only the rack so faulted will be interrupted. All other S.U.T. and Test Controllers will continue normal operation.

4) The Mode Controller contains the interlocked charge and discharge power contactors as well as other circuitry. The charge contactors place the Power Supply (with the series diode and shunt in series) across the S.U.T. -- positive to position, negative to negative. The discharge contactors place the Power Supply positive in series with the S.U.T. negative and the Power Supply negative in series with one side of the load. The S.U.T. positive is permanently connected to one side of the Load, completing the discharge circuit. The Mode Controller also contains a mementarily activated relay circuit which shorts the Power Supply's voltage and current program terminals.

3. Orbit Timing and Mode Transfer Control (Cont'd.)

(TB2-2 to TB2-4, TB2-7 to TB2-8) during all transfers. This circuit is energized by both the Charge and Discharge Coincidence signals when they occur. The circuit is deactivated by either the Start Charge or Start Discharge signals, as appropriate, following a delay of ~ 300 milliseconds (thus reopening the program terminals). The delay assures presence of the desired Current Control Signal early enough to avoid Power Supply runaway (out-of-control current or voltage latches).



START CHG
STOP CHG
CHG/DISCH
VOLT/TEMP DETECTOR
ANALOG SWITCH
RESET PB
CURRENT PROGRAM LOGIC
SWITCHABLE REFERENCE
BOARD 2
PROGRAM REF.
ERROR AMP & CURR. PRGRM OUT
DOD SUB BOARD
BOARD 3
STOP DISCH
START DISCH
ZERO CURR. PRGRM.
ZERO VOLT PRGRM
TB2
2K 5W
1
2
3
4
5
6
7
8
9
10
POWER SUPPLY
CURRENT SENSE
STRING UNDER TEST
T
189Ω AT 20°C
180.5Ω AT 0°C
CURRENT CONTROL SIGNAL

FIGURE 1

582

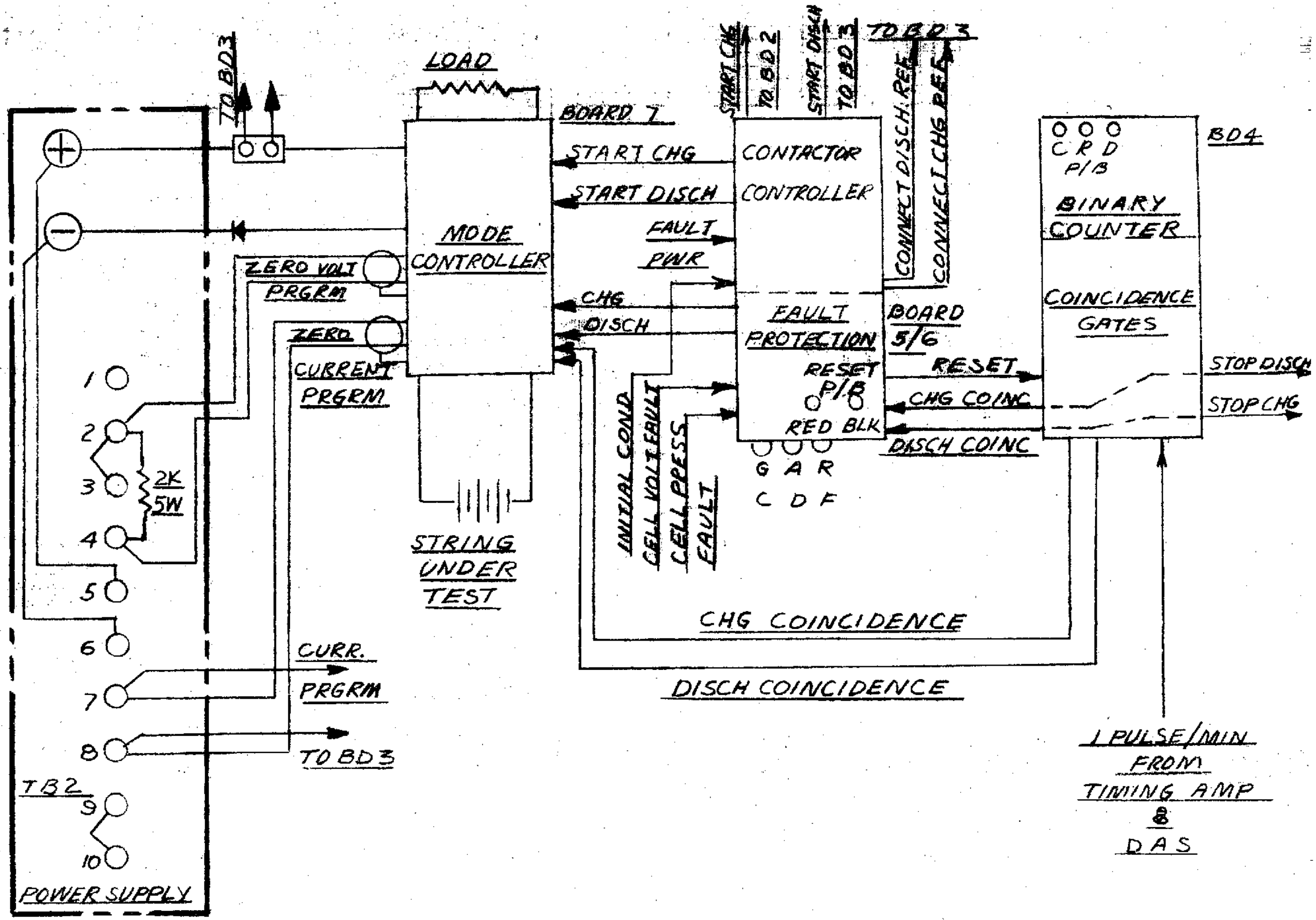

TO BD3
LOAD
BOARD 7
START CHG
START DISCH
FAULT
PWR
MODE
CONTROLLER
ZERO VOLT
PRGRM
ZERO
CURRENT
PRGRM
CHG
DISCH
START CHG
TO BD 2
START DISCH
TO BD 3
TO BD 3
CONNECT DISCH REF
CONNECT CHG REF
CONTACTOR
CONTROLLER
FAULT
PROTECTION
BOARD
5/6
RESET
P/B
RED BLK
G A R
C D F
INITIAL COND
CELL VOLT FAULT
CELL PRESS
FAULT
BD4
C R D
P/B
BINARY
COUNTER
COINCIDENCE
GATES
RESET
CHG COINC
DISCH COINC
STOP DISCH
STOP CHG
2K
5W
1
2
3
4
5
6
7
8
9
10
TB2
POWER SUPPLY
CURR.
PRGRM
TO BD3
STRING
UNDER
TEST
CHG COINCIDENCE
DISCH COINCIDENCE
1 PULSE/MIN
FROM
TIMING AMP
&
DAS

FIGURE 2

APPENDIX Q-2

PRE-REGULATOR/BIAS REGULATOR

Operation

A. Pre-regulator

1. Approximately 28V AC is supplied by each secondary rounding of the toroidal transformer for each section. The "positive" winding is capable of supplying this to a current load of 1.55 AMP DC (2.56 AMP RMS); the "negative" winding can be loaded to 0.65 AMP DC (1.07 - AMP RMS). The noload voltage across the imput 2000-uF capacitor will, in each case be about 34-36 VDC average. The full-load (1.5 AMP DC positive, 0.6 AMP DC negative) voltages at the same point will be 30-32V positive and 31-33V negative with sawtooth ripple as follows:

   - Positive-- 2-3 volts peak-to-0eak
   - Negative-- 1-2 volts peak-to-peak

   The positive side should drop out of regulation, as evidenced by deep negative going spikes seen on a scope across the output capacitors under the following conditions:

   - At 1.5 AMP load-- at or below 100 volts RMS into the transformer primary.
   - At 115V RMS-- at 2 AMP load or greater.

   The same holds true for the negative side, but at loads of 0.6 AMPS and 1.0 AMP respectively. At any primary input voltage between 102 VRMS and 125 VRMS; and any load up to and including full rated, the output ripple and noise of each section should be less than 20 MV peak-to-peak. Output voltage of each section should be 24V±5% nominally (at 115 V input, halfload) and total line and load variation for each should be less than 0.25V.

2. The UA7824 is a packaged device capable of about 10 watts dissipation under the existing conditions of service. It is rated for 1 AMP output with no more than 5 volts between input and output. Since

A. Pre-regulator (Cont'd.)

2. Continued

additional voltage drop is necessary, it must be derated for our use. Hence, the positive side uses the TIP34A as a current multiplier section. Whenever total load is greater than that necessary to turn "on" the TIP34A (accounting for that current through the 3Ω resistor), the two devices share load. The UA7824 will conduct to a limit of about 0.55 Ampere, and all the rest is handled by the TIP34A. When the sum of TIP34A base current and 3Ω resistor current causes too high a base-emitter voltage, an overlaod circuit in the UA7824 causes the input terminal to go highly positive, effectively "opening" up (turning off) both devices, and causing output voltage to drop to limit the load current.

B. Bias Regulator--

1. Plus and minus 24 volts from the pre-regulator is used to power the Bias Regulator. In 3793A zener diode with associated limiting resistors are used to provide internal supply points for the two 741 error amplifiers. A single IN823 zener is used as a reference for the positive side. The +10V output has a total output rating of 0.5 Ampere. The "foldback" circuits act to limit both load current and power dissipation in the pass elements by causing the output voltage to drop faster than an overload can cause the current to rise. The current at which this process starts, called the "corner" current, is:

- +10---1.15 Amp or greater total
- -10V--0.86 Amp or greater

The -10V output is "slaved" to the +10V as that they rise and fall in absolute value together. This avoids common mode supply problems for the 741 amplifiers in the rest of the rack.

2. The +10V side is a simple pass-element regulator. The 741 error

B. 2. Continued

amplifier senses the difference between the reference and the voltage across the lower half of an output divider. The divider is set-in-test so that its lower half drops exactly the reference voltage when output voltage is 10.30V. Any subsequent difference is amplified by the 741 and applied to the base of the 2N697 dirver, altering both its conduction and that of the TIP33 emitter follower to correct the output. The 0.15 uF capacitor acts to reduce output ripple and noise <u>and</u> to AC stabilize the connection loop. The 100 uF output capacitor acts in similar fashion though for different reasons. The parallel 5-watt resistors, in series with the output, sense load current. As long as their drop is less than that across the 750-ohm resistor in the foldback divider, the 2N930 remains off since its emitter is more positive than its base. Once this drop exceeds that across the 750 ohm, the base goes sufficiently positive to turn the transistor on. The 2N930 then bypasses drive current from the error amphilifier to the 2N697 base. This continues until the output voltage falls sufficiently to equalize both the series resistor and 750-ohm drops. Accordingly, both current and output voltage will fall. Ultimately, with the +10 volt output shorted, the short current will be about 30-50 uA. The falling current also provides for reduction in pass transistor dissipation. Maximum dissipation will occur about the correct current, and will be approximately 16-17 watts (1.15 Amp X 14 volts Vce). The foldback process in enhanced by using a backward diode (IN4148) biased from the +24-volt input. Before foldback, all the bias current ($\sim$170 uA) through the 82.5K flows through the diode and the lower part of the foldback divider. Once foldback starts, this current is shared between the diode and the 2N930 base, providing the following:

- Base-emitter voltage and threshold compensation.
- Increased rate of output voltage decay due to loss of the bias in the lower part of the divider.

The -10V side operates similarly, except that the transistors are all PNP types, and a zero reference point is established by the +10V side for tracking. (That is, the 741 compares the voltage at the mid-point of the divider to COM. This mid-point will remain

B. 2. Continued

at COM potential only if the -10V tracks the +10V exactly.

The -10V is 10.30V when the lower half of the divider is set-in-test to be exactly equal in resistance to the upper half). The +5V (actually 6.1-6.5V) is a simple current multiplying type series-pass regulator. Here the output voltage plus the sum of the two base-emitter voltage are equal to the zener (IN755A--~5.5V) voltage. The 5uF output capacitor provides energy storage to decouple changing load. Regulation of the three outputs is as follows (load only):

+10V
-----15mV maximum
-10V

+ 5V------0.25V maximum

Ripple and noise for all three is less than 3mV peak-to-peak

II. Calibration

A. Pre-Regulator-- none required. Check for values quoted above.

B. Bias Regulator

1. With no transistors or chips in place, check that the voltage at the +15V and -15V points are between 13.5 and 16.5V with $\pm$24V applied. Check voltage across IN823 zener. Should be 6.2V $\pm$5%. Shut off power.

2. Lift one end of the 3.65K output divider (+10V) using chip leads, short 741 inverting terminal (Pin 4) to common, and short across IN823. Install +10V 741 amplifier. Apply power. Adjust 10K pot until 741 output voltage (Pin 10 to common) is $\leq$ 0.01V on a DVM. This must hold for at least 5 minutes. Shut off power. Resolder 3.65K and remove shorts.

II. Calibration (Cont'd.)

B. 3. Install 2N697. Place DVM at HDV output to common. Place decade box set at 999K across 7.5K divider resistor. Apply power. Adjust decade box until output is 10.30V$\pm$5mV. Hold for 5 minutes.

4. Install resistors found on decade box setting in S.I.T. position. Apply power and recheck output. Apply 10 Ω load and check regulator. Shut off power.

5. Install 2N930. Apply power. Recheck voltage and regulation for no change from step 4. Decrease load resistance until output voltage drops >100mV. Load resistance should measure 8.7 Ω (load current $\cong$ 1.15 Amp.). Shut off power.

6. Lift one end of the 10K output divider resistor (-10V). Short the inverting terminal (Pin 4) of the -10V 741 amplifier to common with a clip lead. Install the amplifier. Repeat the zeroing procedure of step 1 above on this amplifier. Shut off power. Restore the 10K resistor, and remove shorts.

7. Install 2N1132. Place DVM between -10V output and common. Place decade box set at 999K across 12.1K divider resistor. Apply power. Adjust decade box until output voltage is 10.3V $\pm$5V and holds for 5 minutes.

8. Install resistor(s) in S.I.T. position found on decade box setting. Apply power and recheck output voltage. Apply 17 Ω load and check regulation. Repeat with and without 10 Ω load on +10V. Recheck +10V regulation with and without -10V load. Shut off power.

9. Install 2N2905. Apply power and repeat step 8 above. Decrease -10V load until output drops > 0.100V. Load resistance should be $\geq$11.6Ω. (Load current $\geq$.86 Amp.). With full normal load on -10V, cause +10V to foldback. -10V output voltage should

II. Calibration (Cont'd.)

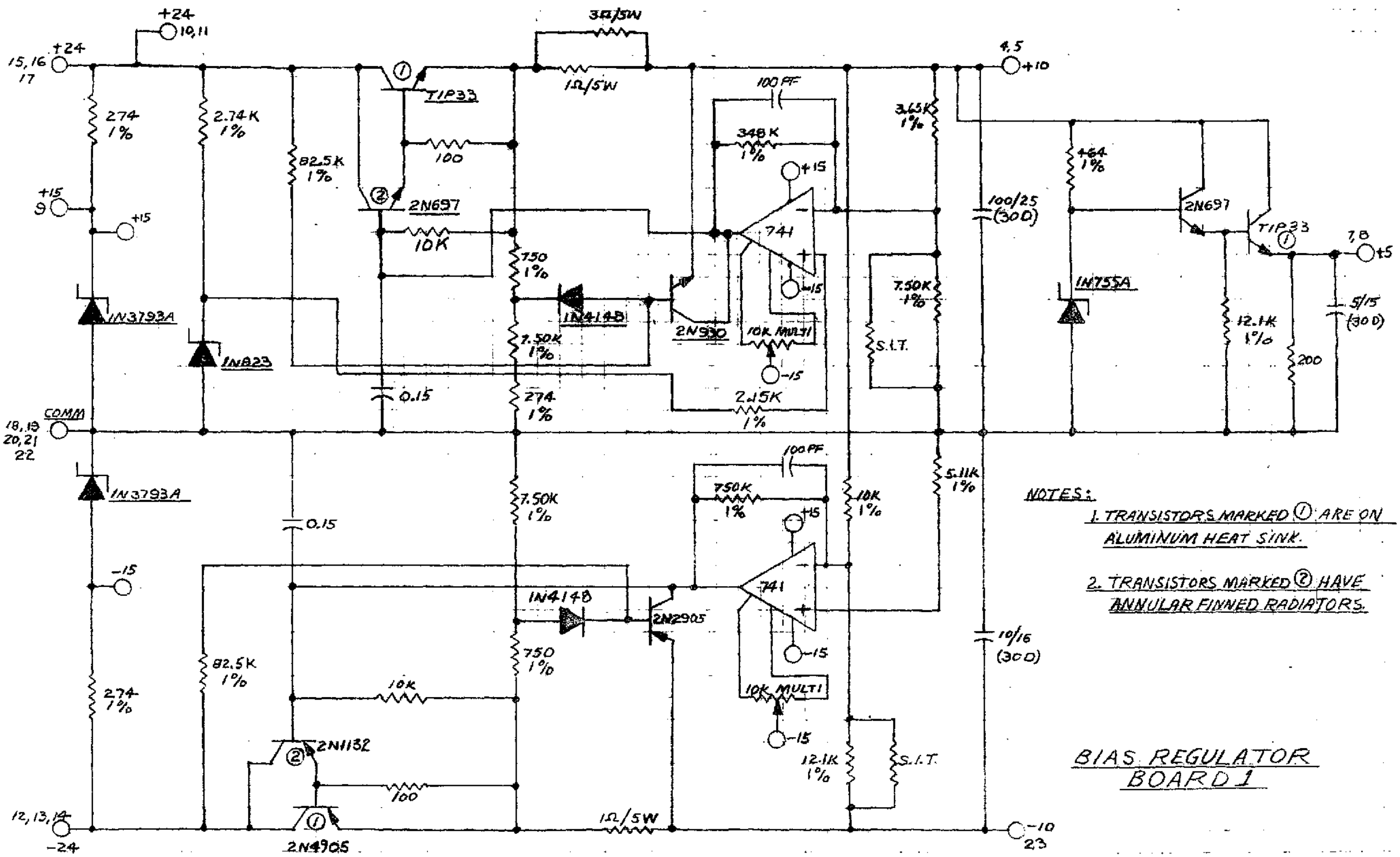
track within $\pm$ 10mV. Repeat with no load on -10V (Note: +10V should not track -10V foldback).

10. Short +10V and -10V outputs in turn through milliameter. Current should be less than 50mA in each case. (Note: to protect milliameter, set it on a high range at first, then move down until current is readable.).

11. Install +5V 2N697. Output voltage should be 6.1 to 6.5V.

With and without 13.5Ω load on +10V and 17Ω load on -10V, check load regulation of +5V from open circuit to 15Ω load.

12. If the foldback corners of steps 5 and 9 are out of tolerance (less than desired current), the current can be raised by adding resistance in shunt with the common side of the dividers. Place the decade box across the desired part, set at 999K, and reduce until the required level is achieved.



NOTES:

1. TRANSISTORS MARKED ① ARE ON ALUMINUM HEAT SINK.

2. TRANSISTORS MARKED ② HAVE ANNULAR FINNED RADIATORS.

BIAS REGULATOR
BOARD 1

APPENDIX Q-3

VOLT/TEMP DETECTOR

I. OPERATION --

A. The detector itself consists of a voltage divider connected across the string under test, a differential amplifier (allowing the string to "float" with respect to the test controller common), an amplifier whose gain is sensitive to string temperature, a fixed gain amplifier, a reference, and a comparator/analog switch.

The string voltage is divided by the 2K resistor and RD. RD has a value of 10K per cell of the string.

Typical values are:

- 1 cell 10K, 1%
- 2 cell 20K, 1%
- 3 Cell 31.6K, 1%
- 4 cell 41.2K, 1%

The two capacitors across the divider (and the one across TB1-19/TB1-20) provide noise pickup suppression. Amplifier A7 is a unity-gain differential amplifier whose junction is to isolate the divided voltage with respect to board common. String temperature is sensed by a 200 Ω nominal positive-temperature coefficient (0.0047 $/^{\circ}C$) nickel resistor which is connected as part of the feedback loop of A8. Using the values given in the calibration section below, the gain of this amplifier is as follows:

- S.U.T. Temp = $0^{\circ}C$ -- 2.585
- S.U.T. Temp = $20^{\circ}C$ - 2.685

Processing A7's output through A8, then, provides the desired temperature sensitive slope to the sensed voltage, since, at any string voltage, A8's output will be higher at $20^{\circ}C$ than at $0^{\circ}C$.

A8's output is then inverted and increased by fixed (gain of 10) amplifier A9 for comparison with the reference at the input to A10. (A7's and A8's output are negative with respect to common; A9's output is positive.)

A9's output resitor (10K, 1%) is both a load on A9 and a summing resistor to A10.

A switchable, controllable reference is used. The actual value of the reference voltage (output of A11 buffer) determines the level at which A10 will trip. Three levels of voltage-temperature curves are set in the S.I.T. group. With no switches closed, the lowest level is set (L1). The nominal level is set by shunting L1's resistors upon closure of L2's switch. The highest level is set by further shunting with L3's switch.

A10 functions as a comparator and analog switch. As long as the processed string voltage is below trip level, A10's input (at the inverting terminal) is negative, and the switch is "ON" -- high output. This output is held to about 4 volts by the action of the IN750 zener in A10's feedback loop. When the string voltage reaches the desired level, the input to A10 swings slightly positive. The open loop gain of A10 ($\geqslant$40,000), combined with the regenerative network between the output and the non-inverting terminal, causes the output to switch to its full negative value. This is clamped by the diode at the output terminal to about 0.8 volts. The back-to-back parallel diodes between the input terminals protect the amplifier by limiting the differential input signal to a safe value.

A10's output is used to "clock" a set of J-K flip-flops (9099) connected as a filled storage register.With the J-K terminals of F/FI connected as shown, the first negative transition of A10 causes the $Q - \overline{Q}$ output to change state -- Q becomes +5V (logic "1"), and $\overline{Q}$ becomes OV(logic "0"). F/FII is then set so that A10's <u>next</u> transition will change its output state, and so on. As each $\overline{Q}$ becomes OV, the connected 946 gate output becomes logic "1" (+5V), turning on the 2N2905 transistor connected to it. As will be seen in the description of Board 3, this action causes the change current step-down programming desired.

Since the above actions occur only on rising string voltages, Board 2 has no function during discharge periods.

A note of caution is necessary here. Sometimes, when an individual test position is reenergized in a charged period, the charge rate may be initially high, and A10's output may be locked down. Such a condition, if allowed to persist, would damage the cells, It is therefore wise, whenever restarting a rack during charge to have either a VOM or a 'scope across A10's output to insure that this does not happen. Simply cycling the Power Supply main switch off and then on will establish a programmable current level.

There are three other functions to be described. The reset lines of the flip-flop (CD) are all connected to a 932 gate used as a logic inverter. The START CHARGE signal sets all three flip-flops so that all $\overline{Q}$'s are logic 1, and all 2N2905's are turned off. This permits the programming cycle to start. For board test purposes, the logic can be manually reset by the pushbutton shown. The STOP CHARGE and TRANSFER to CHARGE signals through individual buffers, diode "OR" gate and another comparator/analog switch (A5) on the clock-overriding SD lines of the flip-flops to cause all 2N2905's to be turned on. These actions assure that all mode transitions occur at low currents.

B. The possible proposed modification to replace the scanning under/over voltage detector is shown in note 2 of the schematic. In it, the divided string voltage is amplified by a X10 inverter and applied to a A711 continuously reading dual comparator. The references for this are derived from the +10V bus. If cell voltages are such that the string total is $\gtrsim N_{cells}$ X 1.65V or $\gtrsim N_{cells}$ X 1.05V, either the high or low comparator will have a positive output. This is buffered by two transistors and used to drive a pair of small relay coils, whose contacts pilot the main fault relay (K3 on board 5/6).

II. CALIBRATION

1. Using a decade box, set the total value of the resistor group labeled (3) on the schematic to 285.5 $\pm$ 0.5 . Install indicated 1% film resistors and recheck. A wheatstone bridge must be used.
2. Again with a decade box, set the total value of the resistor group labeled (4) to 105 $\pm$ 0.5 . Install indicated 1% resistors and recheck.
3. Install A7 and A8. Connect a 180Ω $\pm$ 0.5Ω resistor across P2 -10 and P2-11. Short each side of the 2K divider resistor to common using clip leads. Connect a DVM between A8 output and common. Apply bias power to the board. Adjust the 10K Multiturn pot until A8's output is 0.000V $\pm$0.010V. Hold for 5 minutes. Turn off bias power and remove short
4. Connect the PDI cell simulator power supply across P2-12 (positive) and P2-13 (negative). The chassis of the supply should be connected to shield ground. Connect a 'scope across A10 ouptut. (The 'scope should be set for 2V/Cm, and the zero level carefully established.) Install A9, A10, A11. With both switches open (up position), place a decade box across the L1 resistor position. The box should be initially set to 600Ω. Apply bias power. Turn on cell simulator supply.

4. (Continued)

Carefully adjust the cell simulator supply until its output is 1.530 volts X N_{cells} as measured on a DVM. Adjust the decade box until A10 output is just barely tripping from high to low. Allow set to operate for 30 minutes. Readjust decade box until A10 trips at $[N_{cells}$ X 1.530 volts$]$ $\pm$ 0.005V. Shut off bias power and install indicated 1% film resistors. Reapply bias power and verify.

5. Close L2 switch. Place decade box across L2 resistor position, set at 999K. Adjust box until A10 trips at $[N_{cells}$ X 1.560 volts$]$ $\pm$ 0.005 volts. Continue operation until this value is stable. Shut off bias power and install indicated 1% film resistors. Reapply bias power and verify.

6. Repeat step 4 with L3 switch closed and decade box across L3 resistor position. A10 trip point shall be $[N_{cells}$ X 1.590 volts$]$ $\pm$ 0.005

7. Shut off bias power. Connect a 199.5 $\pm$ 0.5Ω resistor in place of the 180Ω resistor across P2-10 and P2-11. Reapply bias power. Set switches to L1. Adjust cell simulator to N_{cells} X 1.480 volts. After stability is achieved (20-30 min.), A10 should trip at this value $\pm$ 0.010 volts. Set switches to L2 and L3 in turn, and verify that A10 trips at the following:

   L2 -- $[N_{cells}$ X 1.510 volts$]$ $\pm$ 0.010V
   L3 -- $[N_{cells}$ X 1.540 volts$]$ $\pm$ 0.010V.

   Make such adjustments as necessary to achieve all values as shown in steps 3 through 6. Shut off bias power.

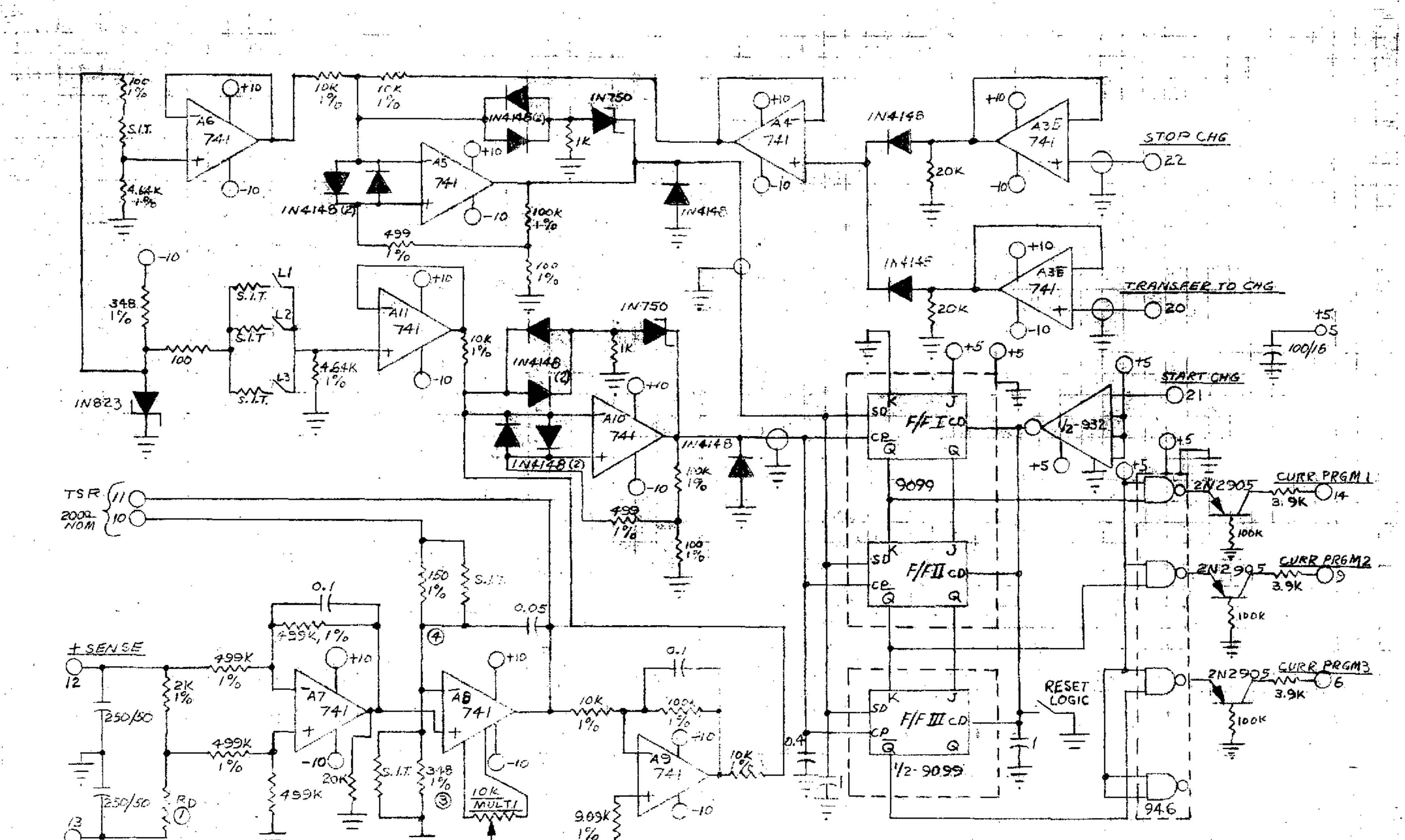
8. Install A3D, A3E, A4, A5, A6. Apply bias power. Place 'scope across A5 output. Place decade box across A6 input S.I.T. position. Set value so that when +4V is applied to either A3D or A3E input, A5 trips. Shut off bias power.

9. Install 9099's, 932 and 946. Connect P2-21 to common. Apply bias power Place 'scope across A10 output.

9. (continued)

Push RESET LOGIC button. Verify that each 946 output is 0V (logic "0"). Cause A10 to trip once only. Verify that number 1 946 output is logic "1" (4-6V), and both others are zero. Retrip A10. Verify that number 1 and 2 output are logic "1", and number 3 is zero. Retrip A10 again. Verify that all three are now one. Retrip A10 again. Verify that no change occurs. Connect P2-21 to +5V. Verify that all 946 outputs are zero. Reconnect P2-21 to common. Apply +4V to A3D. Verify that all 946 outputs are one. Reset logic. Apply +4V to A3E. Verify that all 946 outputs are one.

10. If proposed modification is in, verify that high comparator closes relays when cell simulator voltage is $\left[N_{cells} \times 1.65V\right] \pm 0.101V$, and that low comparator acts when cell simulator voltage is $\left[N_{cells} \times 1.05V\right] \pm 0.010V$.



VOLT/TEMP DETECTOR
BOARD 2

NOTE: 1. RD IS 10K/CELL, 1%
2. FOR ③ & ④, SEE CALIBRATION INSTRUCTIONS

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APPENDIX Q-4

CURRENT CONTROL

I. OPERATION

This control utilizes a shunt as the current sensing element, isolates and amplifies its drop, compares the result to a programmable reference, and uses the error signal to control the current output of the Power Supply through its current programming terminals.

The programmable reference, a series of constant current sources supplying fixed resistors, is controlled by the program logic of Board 2 in charge mode, and by the START DISCHARGE/STOP DISCHARGE logic in this board. Which reference circuit (charge or discharge)is connected to error amplifier A2 is controlled by K1A contacts in Board 5/6. The charge side contains Q1 through Q4 with their collector resistors R1 through R4. The voltage drops across R1-R4 are summed in summing amplifier A3, whose output is inverted in A5. When A5's output is connected to the divider driving A6, it becomes the charge reference. By setting the current through Q1-Q4 emitters with the sub-board emitter resistors, the contribution of each load resistor to A3 is controlled. The contribution of each load resistor to A3 is controlled. Q6-Q8 short R1-R3 to common in turn when turned on by the logic of Board 2.

The discharge side includes Q5, R5, A4, F/FI, GI, Q9 and Q10. Q5, R5 and A4 set the discharge reference. F/FI, GI, Q9 and Q10 act to short R5 to common in the STOP DISCHARGE period by logic similar to that on the charge side. The only differnece is that once a STOP DISCHARGE command is received, R5 will remain shorted until both that command has disappeared <u>and</u> a START DISCHARGE is issued and received. This accounts for the necessity to manually mode cycle the rack when first turned on in order to start a discharge at the correct level.

The DOD sub-board contains the emitter resistors for Q1-Q8. Those for Q1-Q4 and Q6-Q-8 will be identical on all three DOD boards for any given rack. Those for Q5 will vary depending on the DOD desired (12%, 30% or 50%).

The shunt signal is recieved by A1 and differentially amplified with a gain of 10. It is compared to the programmed reference in A2, a differential amplifier with a gain of 3.16 for the error, and unity for the floating Power Supply program termianl (e, at P3-22). The amplified error is differentially buffered in A7 and A8 to produce a programming voltage from a source capable of sinking 1mA of current used in the Power Supply current control network.
A further word about the reference. The biased backward diodes in the base circuits of the constant current generators, Q1-Q5, provide both base-emitter temperature compensation and more accurate control, since their drops subtract from the base-emitter drops of Q1-Q5.

II. CALIBRATION

1. All transistors and chips should be out. Install A1 and A2. Short P3-9/11 and P3-8/10 to common. Short A6 pin 10 to common. Short A8 pin 5 to common. Apply bias power. Adjust 10K multiturn pot such that A2 output is 0.000V ± 0.010V. Hold for 5 minutes. Shut off bias power. Remove shorts.
2. Install A3 and A5. Short R1-R4 to common. Apply bias power. Switch to charge mode. Adjust A3's 10K multiturn pot such that A5 output is 0.000V ± 0.010V. Hold for 5 minutes. Shut off bias power. Remove short from R4 only.

3. Install Q4. Install a DOD sub-board. Place decade box across Q4 emitter resistor. Apply bias power and switch to charge. Adjust decade box such that A5 output (across 9.09K/1K divider) is 0.250V $^{+0.020\text{V}}_{-0}$

Shut off bias power. Install next higher value of 1% film resistor. Adjust decade box to 999K. Reapply power. Adjust decade box until A5 output is 0.250V ± 0.001V. Shut off power and install indicated resistor values. Reapply power and verify A5 output. Hold for 5 minutes. Shut off bias power and remove the short from R3.

4. Install Q3. Place decade box across Q3 emitter resistor positions. Repeat step 3 above except that the A5 output values shall be:

- Initial - - 1.000V $^{+0.020\text{V}}_{-0}$
- Final - - 1.000V ± 0.001V

Shut off bias power and remove the short from R2.

5. 5. Install Q2. Place decade box across Q2 emitter resistor position. Repeat step 3 above except that the A5 output values shall be:

- Initial - - 2.500V $^{+0.020\text{V}}_{-0}$
- Final - - 2.500V ± 0.001V

Shut off bias power and remove the short from R1.

6. 6. Install Q1. Place decode box across Q1 emitter resistor position. Repeat stip 3 above except that the A5 output values shall be;

- Initial - - 4.167V $^{+0.020\text{V}}_{-0}$
- Final - - 4.167V ± 0.001V

Shut off bias power.

7. Install Q6. Place decade box across Q6 emitter resistor position. Operate with Board 2. Apply bias power. Trip detector once. Adjust decode box until A5 output is 2.500V $^{+0}_{-0.020\text{V}}$. Install next higher value resistor after shutting off bias power. Reapply bias. Retrigger detector.

7\. (Cont'd.)

Adjust decade box until A5 output is $2.500V^{+0}_{-0.020V}$. Install next higher value resistor after shutting off bias power. Reapply bias. Retrigger detector. Adjust docade box until A5 output is 2.500V $\pm$0.001V. Shut off bias power. Install resistor and reverify.

8\. Install Q7. Place decade box across Q7 emitter resistor position. Apply bias power. Trigger detector twice. Repeat step 7 above except A5 output shall be:

- Initial - - $1.000V^{+0}_{-0.020V}$
- Final - - 1.000V $\pm$ 0.001V.

Install resistors, verify.

9\. Install Q8. Place decade box across Q8 emitter resistor position. Apply bias power and trigger detector three times. Repeat step 7 above, except A5 output shall be:

- Initial - - $0.250V^{+0}_{-0.020V}$
- Final - - 0.250V $\pm$0.001V

Install resistors. Verify all steps.

10\. Install Q5. Place decade box across Q5 emitter resistor position. Apply bias power. Switch to discharge. Repeat step 3 above, except the output to be measured is that of A4 (still across 9.09K/ 1K divider), and the values are as follows:

DOD	Initial	Final
12%	$1.000V^{+0.020V}_{-0}$	1.000V$\pm$0.001V
30%	$2.500V^{+0.020V}_{-0}$	2.500V$\pm$0.001V
50%	$4.167V^{+0.020V}_{-0}$	4.167V$\pm$0.001V

Shut off bias power, install indicated resistors for each sub-board, and reverify each. Label each sub-board with rack S/N & DOD.

11. Using any sub-board from the above, install Q9, Q10, GI and F/FI. Disconnect the board lead to P3-12, and connect it to common with a clip lead. Connect decade box across Q10 emitter resistor potition. Apply bias power. Switch to charge,then discharge. A4 output should be commensurate with the DOD sub-board. Move the clip lead to +5V, and return to common. Adjust the decade box until A4 output is 0.250 V or less. Shut off bias power. Install indicated resistor. Reapply bias power, cycle modes, and reverify that when clip lead is moved to +5V momentarily A4 output drops from normal value to 0.250V or less. Reconnect lead to P3-12.

12. Install all remaining chips. Connect rack to test circuit with Power Supply using power shorting jumper in S.U.T. position. Connect leads from shunt to rack TB1-12 and TB1-13. Disconnect programming leads between rack and Power Supply TB2-7 and TB2-8. Verify that P3-22 is connected to TB1-2 of rack, and connect VOM to programming lead such that positive is to TB1-2. Connect link on Power Supply TB2-7 to TB2-8. Turn on bias power, cycle mode, finishing in charge. Turn on Power Supply. Using front panel, controls, verify that when current is increased, programming signal output decreases. If not, reverse connections to shunt. Turn off all equipment and return Power Supply front panel currenct controls to zero (fully CCW). Remove Power Supply TB2-7, TB2-8 link and reconnect programming leads.

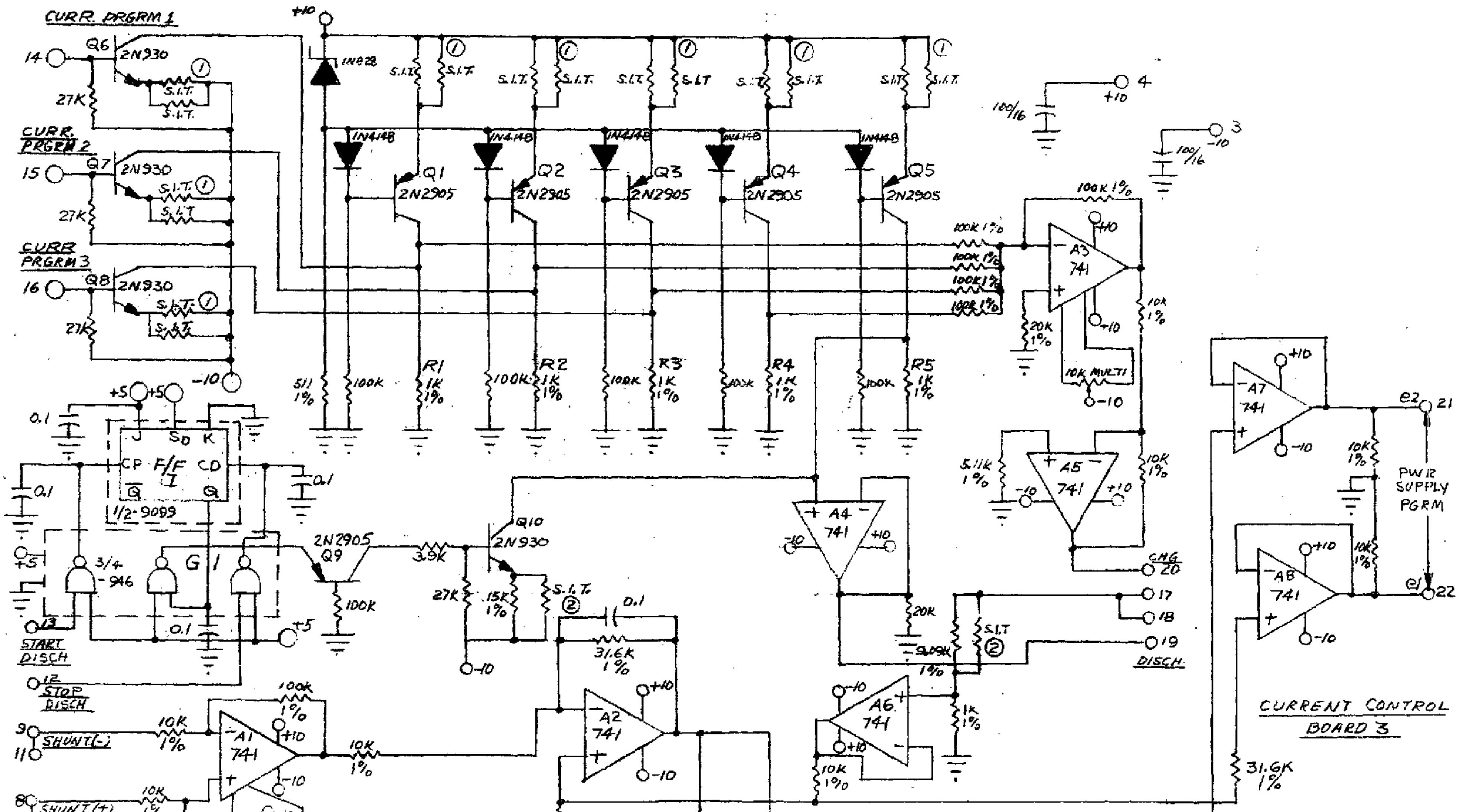
13. Connect DVM across shunt to read current accurately. Turn on bias power. Cycle modes, finishing in charge. Connect decade box set at 999K across 9.09K in A6 input divider. Turn on Power Supply Adjust decade box until currenct is 83.3 AMP $\pm$ 2.0 AMP (41.65 mV$\pm$ 1.00mV). Trigger board 2 detector once. Currwnt should be 50.0$\pm$ 1.5 AMP (25.00$\pm$ 0.75mV) Retrigger detector. Current should be 20.0 $\pm$ 1.0 AMP (10.00 $\pm$ 0.50 mV). Retrigter detector. Current should be 5.0 $\pm$ 0.25 AMP (2.50$\pm$-0.12mV) - Since the most critical tolerance is low level trickle charge, re-

13. (Cont'd.)

adjust decade box as necessary to achieve the required value. Depress board 2 reset and recheck all other points. Readjust any sub-board resistors required to achieve correct tolerances. Switch to discharge. Discharge currents shall be as follows:

DOD	CURRENT	mV
12%	20.0±1.0AMP	10.00± 0.50
30%	50.0±1.5 AMP	25.00± 0.75
50%	83.3±2.0 AMP	41.65±1.00

Readjust Q5 emitter resistor(s) as required. Verify the above numbers on <u>all</u> subboards. Turn off all equipment.



NOTES: 1. ALL RESISTORS MARKED ① ARE ON PLUG-IN SUB-BOARDS THERE IS ONE SUB-BOARD FOR EACH D.O.D.
2. THE RESISTORS MARKED ② ARE ON THE MAIN BOARD

COUNTER/COINCIDENCE

I. OPERATION --

The counter (chips 1-7), is a 7-stage binary counter using DTL logic. As each clock pulse is received at P4-7 and P4-6, it is AC-coupled through the 4uF capacitor and the DO-T41 pulse transformer, and turns on the 2N697 transistor. The transistor's collector thus goes from a high, clamped positive value ($\sim 4V$) to common potential, producing a zero-going transistor on the clock line. With all count outputs at zero, the first such pulse sets 2^0 to a one, the second to zero, while 2' goes to one. The third sets 2^0 to one while 2' remains. The fourth sets 2^0 and 2' to zero while 2^2 goes to one and so forth. If there were no reset (chips 18B), the 128th pulse would set all outputs to zero.

Since the orbital time parameters are:

- 36 minutes discharge
- 58 minutes charge
- 94 minutes total,

it is desired to achieve discharge coincidence on <u>count 1</u>, charge coincidence on <u>count 37</u>, and clear (reset) the counter on <u>count 94</u>. <u>Count 95</u> is then really <u>count 1</u> again.

The DISCHARGE coincidence gate is connected to produce a one output when and only when the counter output has a one on the 2^0 line only (all other outputs low.) Thus when 2' - 2^6 are zero (B - G), all I15 outputs are one; G14A andB outputs are zero; G13A and B outputs are one. Only when 2^0 (A) output is one will G14C output be zero, and G13C output will be one. This action can only be overridden by the SET IN DISCHARGE switch. As soon as 2'(B) goes to a one (and 2^0 to a zero), the coincidence is destroyed.

The CHARGE coincidence gate can be sililarly analyzed to produce a one output only when 2^0, 2^2 and 2^5 outputs (A, C and F) are one, and all others are zero. This is count 37(1 + 4 + 32). Coincidence action is bypassed by the SET IN CHARGE switch. This gate also provides the TRANSFER TO CHARGE signal for Board 2.

The CLEAR gate is identical to the CHARGE gate except that it has one more inversion stage (I 18B) to produce a zero coincidence at the counters' reset lines on count 94. ($2'$, 2^2, 2^3, 2^4 and 2^6 are one, the others are low). Action is bypassed by the CLEAR COUNTER switch or a reset command from Board 7.

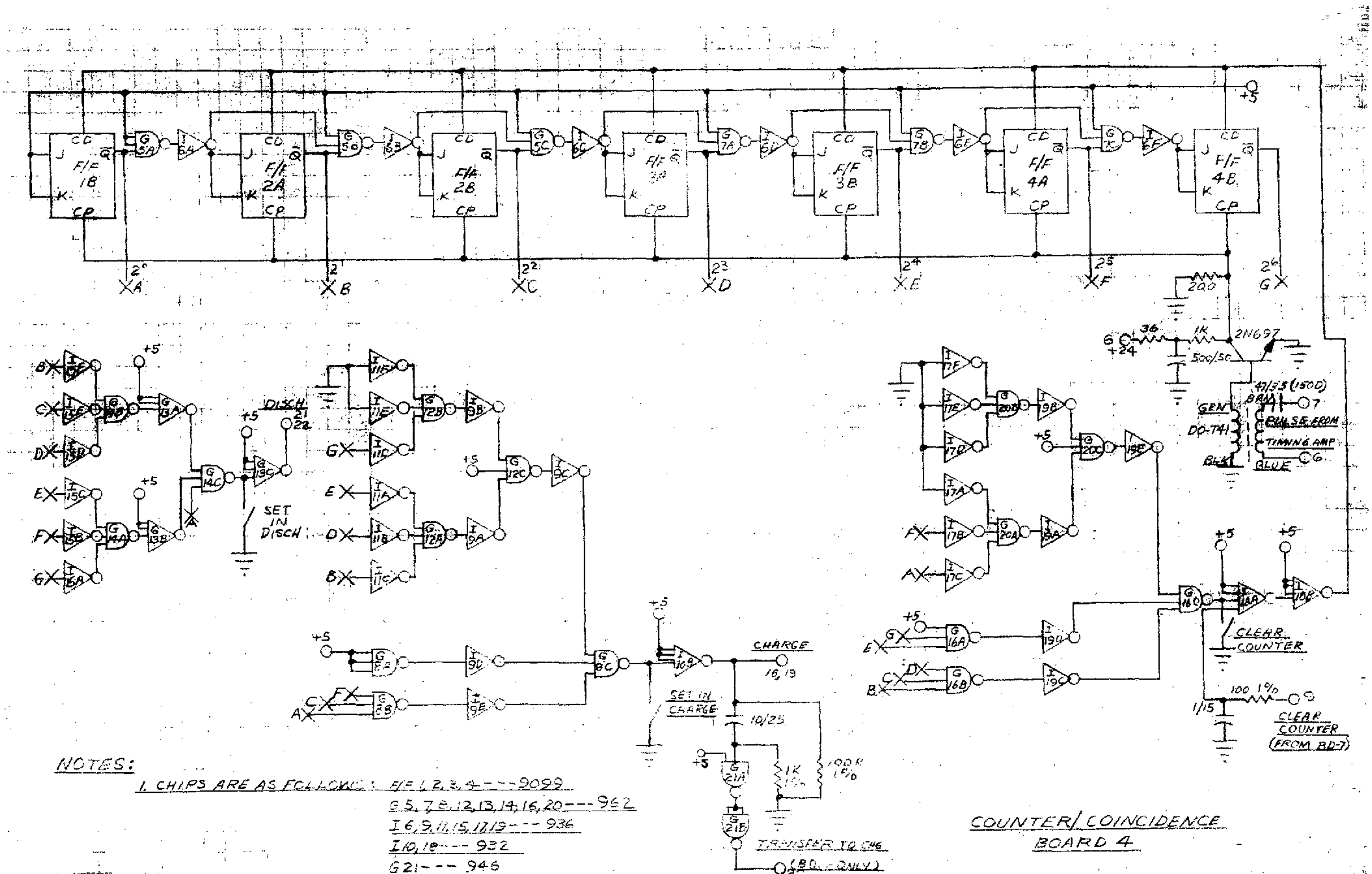
II. VERIFICATION

Operation is best verified by connecting the pulse input to the board (P4-7, P4-6) to the pulse simulator built for this purpose. A'scope, triggered by the pulse itself, should be used to display each pulse. Counting can be done visually. Connecting VOM's to P4-22/21 (discharge) and P4-18/19 (charge), negative sides to common, will allow observation of the coincidences. Once bias power is applied, and the timing pulses are seen, depress the CLEAR COUNTER button. Hold for two pulses duration. Release. On the next pulse, count 1, discharge coincidence should come up. On count 2, it should disappear. On count 37, charge coincidence should come up. On count 38, it should disappear. On count 95 (count repeated) discharge coincidence should reappear.

If problems occur, verify the following:

1. 2N697 output (clock line) has zero-going pulses (from ~ +4V) for each input pulse. Each pulse should be 1.25 milliseconds wide.
2. 2^0 stage output changes state every pulse, $2'$ stage every other pulse, 2^2 stage every 4th pulse, etc.
3. Signals are received and transmitted through each gate element in accordance with the above analyses.

Replace any faulty component.



NOTES:

1. CHIPS ARE AS FOLLOWS: F/F 1,2,3,4 --- 9099
G 5,7,8,12,13,14,16,20 --- 962
I 6,9,11,15,17,19 --- 936
I 10,18 --- 932
G 21 --- 946

2. ALL UNUSED F/F INPUTS ARE CONNECTED TO +5V

COUNTER/COINCIDENCE BOARD 4

APPENDIX Q-6

CONTACTOR CONTROLLER/FAULT PROTECTION

I. OPERATION --

A. Contactor Controller

This device controls the positions of the main contactors in board 7, and thus the operating mode of the test position. Delays are included to provide for low currenct switching, and controlled increase of current at the start of mode. The basic functions are provided by K1A, K2A, K1, K2, K4A and their associated networks.

When bias power is applied, depressing the red power fault reset button energizes K4 and K4A, permitting connection of the +24V return to K1, K2. The circuit will come on in whatever mode it was left. If in charge, depressing the SET IN DISCHARGE button on board 4 will, after a delay of about 120 milliseconds set K2A and reset K1A. This will close K1A's 8-9 contacts and K2A's 9-10 contacts placing +24V at point D and P6-22. K/A's 5-6 contacts will also be closed connecting the discharge reference in board 3. After a further delay of ~ 200 milliseconds, the TIP 33 energizing P6-21 will come on, energizing K1A in board 7. After an additional delay of ~ 200 millisecond (400 milliseconds total after point D is energized), K1 will turn on with the following results:

1. The amber light will light (K1, 6-7 closes)
2. The START DISCHARGE signal is sent to board 3 (K1, 8-9 opens)

A similar description can be given for the transfer into charge.

When the initial condition (synch reset) supply is turned on, board 7's K6 sends a +10V signal to P6-5, resetting both K2A and K1A. After this supply is turned off, the next timing pulse sends a discharge coincidence to this board through board 4 setting K2A.

B. FAULT PROTECTION

1. Power Fault -- When the red power fault button is depressed (following bias power turn-on or an actual fault), K4 is energized. This enables K4A as described above. The red fault light is extinguished, and the ignore data circuit is opened. If either +10V or -10V, or both, collapses sufficiently to drop the IN 3793A zener below its conduction region, the TIP 33 transistor turns off, deenergizing K4, and reversing the above process. The removal of the controlled return (point A) drops out the main contactors by removing power from their pilot relays drivers. Although there have been inadvertent power fault dropouts, all these have been traceable to poor, solder joints, loose or difficulty in board 1.

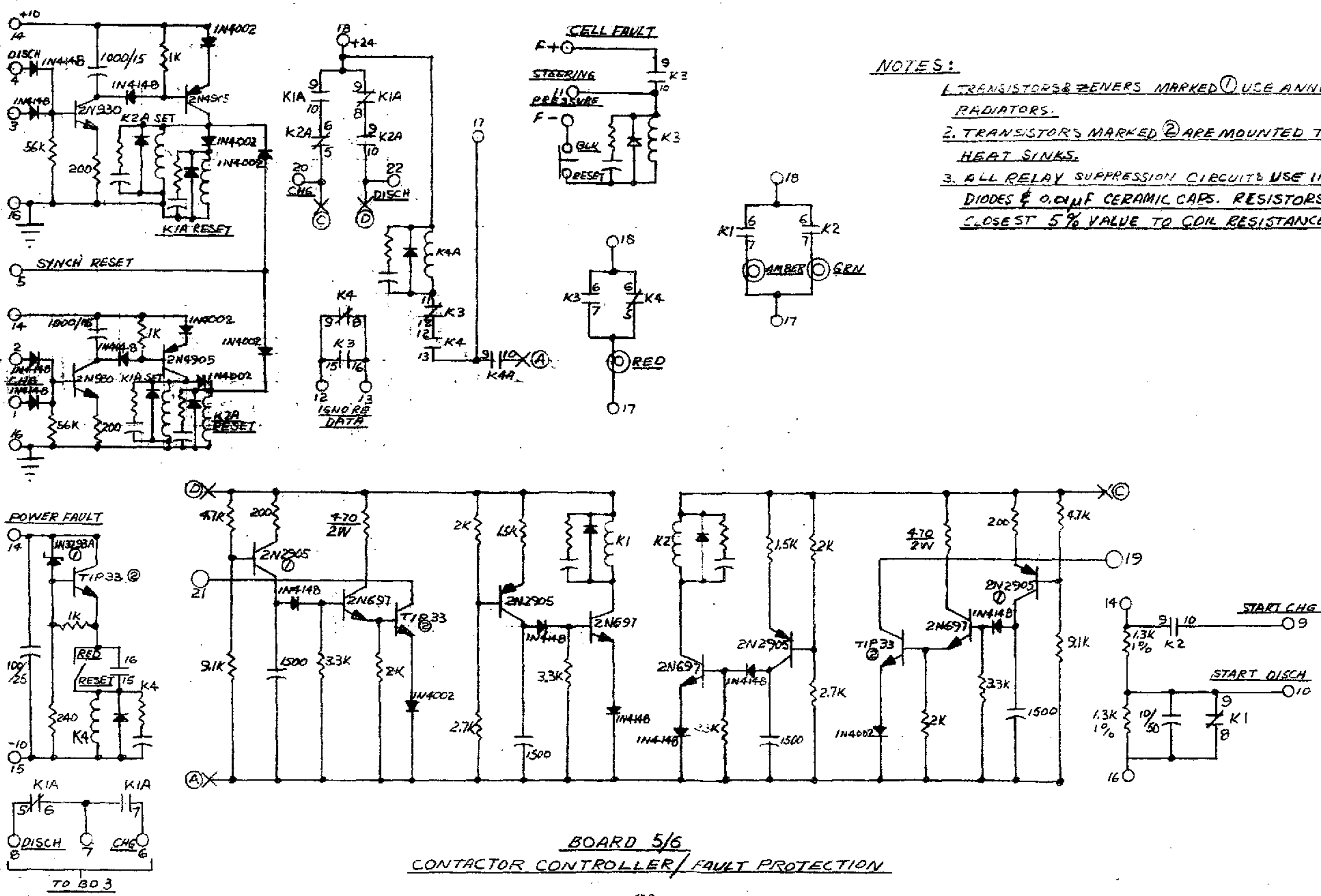
2. Cell Fault -- Two types exist:

   - Cell under or overvoltage
   - Excess cell pressure.

   If the over/undervoltage scanner sees an out-of-tolerance cell, its steering contacts (connected between F+ and P6-11) close, energizing K3. If any of the cells has pressure $\geq$85PSIG, its gauge switch (also connected between F+ and P6-11) closes, energizing K3. This produces the same result as that described for power fault above. However, it can only be reset by the black button directly below the lights. Although there have been inadvertent trip outs here, too, these were traceable to problems in the over/undervoltage scanner.

II. VERIFICATION

Verification of the operation of board 5/6 can best be done in conjunction with board 7. It will be discussed there.



NOTES:
1. TRANSISTORS & ZENERS MARKED ① USE ANNULAR RADIATORS.
2. TRANSISTORS MARKED ② ARE MOUNTED TO HEAT SINKS.
3. ALL RELAY SUPPRESSION CIRCUITS USE 1N4148 DIODES & 0.01μF CERAMIC CAPS. RESISTORS ARE CLOSEST 5% VALUE TO COIL RESISTANCE

BOARD 5/6
CONTACTOR CONTROLLER/FAULT PROTECTION

APPENDIX Q-7

MODE CONTROLLER

I. OPERATION --

This board (sometimes called the "tray") provides direct control of the connection among the String Under Test, the Discharge Load and the Power Supply. In addition, it contains the following functions:

1. Initial Condition (Synchronizing) reset
2. Application of +5V to counter (not used)
3. Program Reset (start charge current) to board 2
4. Zero current and Zero Voltage Programming to the Power Supply for all transistions.

When K1A or K2A are energized by the drive circuits of board 5/6, they pilot the main contactors, connecting the power elements in the appropriate mode.

When the initial condition supply is switched on, K6 energizes. Contacts 9-10 provide the clear counter signal to board 4.

The charge coincidence signal is received by A1 from board 4, applying, through the transistor circiit, an energizing pulse to the set coil of K10. Contacts 9-10 act through P8-11 and P8-12 to short the voltage programming of the Power Supply, driving the Supply's output voltage to zero. Contacts 6-7 perform the same function for the current programming. The start charge signal, generated by the delayed action of K2 in board 5/6, is capacity coupled from P-8-22 to the transistor circuit driving K7. K7's 5-6 contacts provide the board 2 reset, and, through A3 and its associated circuit, a reset pulse for K10, reenabling the Power Supply current and voltage programming. The discharge coincidence and start discharge coincidence and start discharge signals act on K10 thru A2 and A4 respectively to provide zero programming during transition to discharge.

There is a K8 on this board, It has no function. It should be left out of all future builds.

II. VERIFICATION

1. Set up the rack with the PowerSupply, Load (appropriate for the DOD sub-board in board 3), the cell voltage simulator, a DVM to measure current, and the pulse simulator. Also needed will be a 'scope and some VOM's.

2. Turn on bias power only. Depress the power fault reset (red button on board 5/6). Verify that the red light goes out, and either green (charge) or amber (discharge) light comes on. The sound of the main contactors closing should be audible. If the red light goes out, but nothing else happens, or if no sound is heard, check the following with a VOM:

   a) Either the discharge or charge contactor coils have no voltage.

   b) The pilot relays on board 7 have no voltage (K1A, K2A) on their coils

   c) +24V does not exist between points D and A or points C and A on board 5/6.

   Starting with a) true, either b) and or c) must be true, or K1A or K2A is faulty, or there is one or more wires missing or open, or there is a cold solder joint. If a) and b) are true, but c) is not true, the problem exists in the rack wiring between board 5/6 and board 7, or the drive circuits energizing P6-21 and/or P6-19 do not function, or again there are missing or open wires or cold solder joints internal to the boards. If all three are true, K1A, K2A, and /or K4A on board 5/6 is not operating. Look for faulty components, missing or open wires, or cold solder joints. A final, but remote possibility, is that K3's (board 5/6) 9-10 contacts are welded or bypassed, energizing K3. (In this case, the red light will not go out).

3. After clearing up the problems listed in 2 above, leave the rack in charge. Now depress the discharge button on board 4 while observing K10.

3. Cont'd.

It should be seen to set, then reset during the transition. Repeat this when the charge button is depressed. (Always wait about 1 minute between transitions). The same action should be visible. If a set is seen in one transition, and a reset in the other, the reset of the first transition is faulty. Signal trace the appropriate reset circuit to find the trouble, (If this is the charge, verify the presence of the board 2 program reset at P8-21) If there is one set and no subsequent reset or set, the reset amplifier circuit is faulty. Signal track with the 'scope. If there is no action,check to see whether P8-11 and 12 and/or P8-5 and 6 are closed or open. If they are closed, there is no reset action(K10 has set and stayed set); so repeat the above check of the reset amplifier. If open, there is no set. Check the set amplifier.

4. Connect the Power Supply and Load to Board 7, and use a power short in the S.U.T. position. Turn on bias power. Reset the power fault. Cycle the modes, ending in charge. Turn on the cell simulator. Turn on the Power supply. Verify that all current steps are correct, and that correct voltage causes programming. After reaching the trickle level depress the discharge button on Board 4 while observing the Power Supply meters. Verify that, during transition, both meters go to zero, and rise from zero after mode is established. Verify that discharge current is correct for the sub-board used. Return the rack to charge, again verifying zeroing of both Power Supply meters during transition. If problems exist, signal trace the transition operations in accordance with the attached event charts, using a 'scope.

5. With the rack set up and operating per 4 above, turn on the pulse simulator. Depress the clear counter button on board 4. The mode should switch to discharge on the next pulse. Allow the rack to cycle for about 30 minutes with current. Verify that counting is correct during at least two cycles. Verify that progra mming voltage and current steps in charge are correct at least twice.

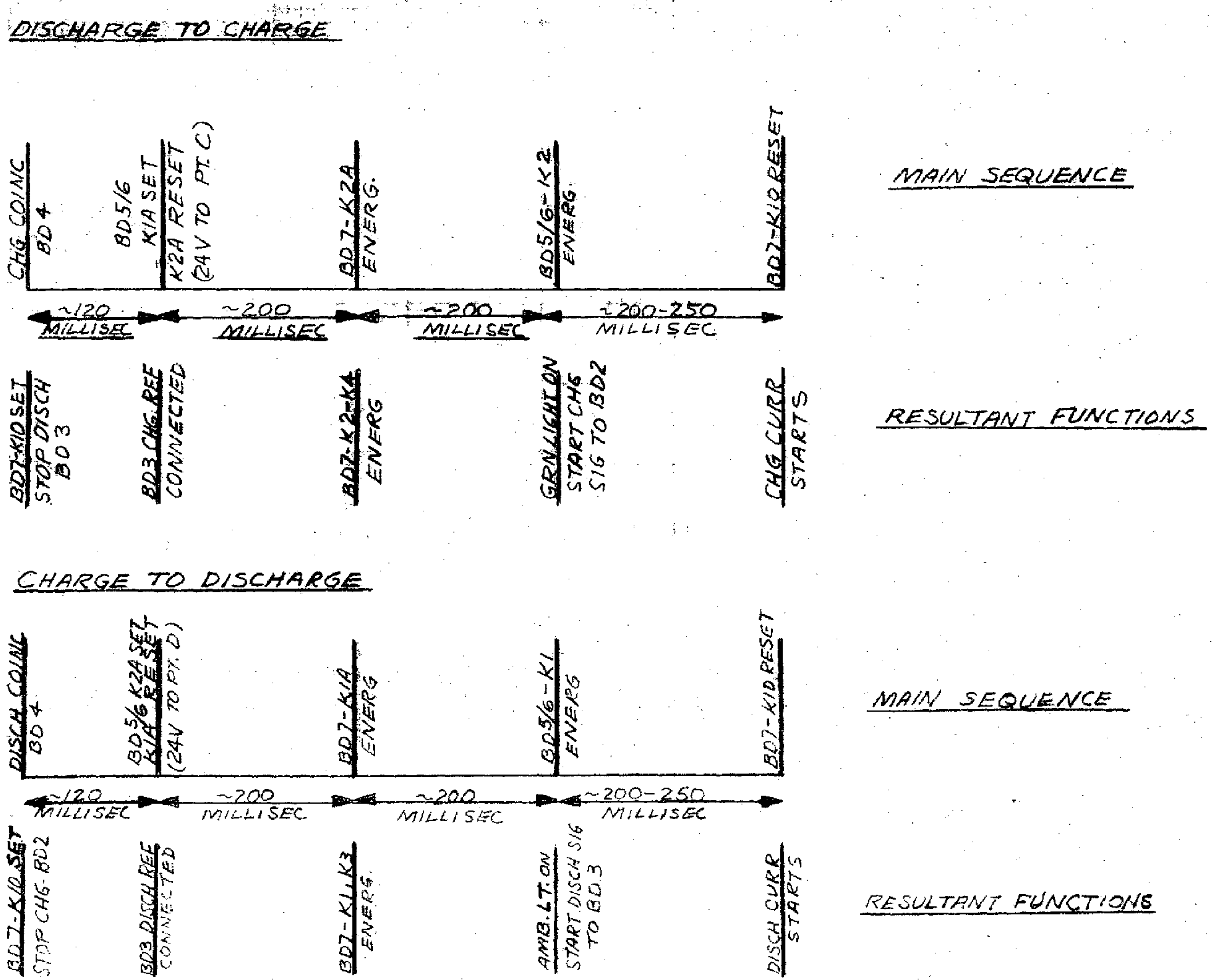
6. Turn off Power Supply, turn off pulse simulator, turn off bias power. Connect the appropriate number of cells of the thermal modules to the S.U.T. position. Replace the cell simulator supply with sense leads from the thermal module. Retain the TSR simulator resistor. Turn on bias power, reset power fault, cycle rack twice, leaving in charge mode. Have a VOM on board 2, A10 output. Turn on Power Supply. Turn on pulse simulator. Depress board 4 clear counter button. Allow the rack to cycle automatically, keeping watch on the transitions to observe the following:

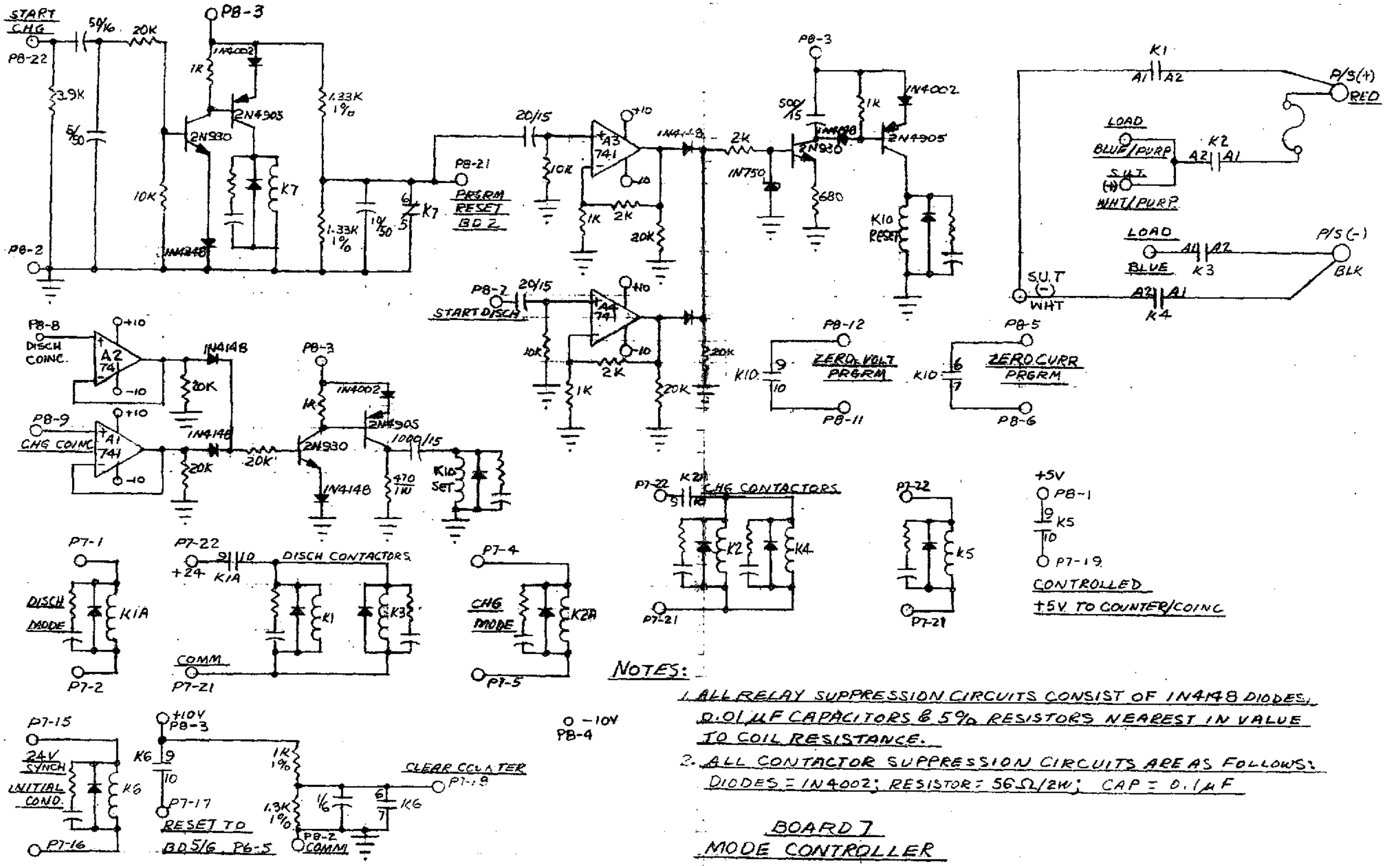
   a) Currents are established in control.

   b) Voltage programming is not locked out at the beginning of charge.

If currents are out of control, repeat steps 3 through 5 of this procedure. If voltage programming locks out, simply turn off Power Supply momentarily, turn on again, and allow cycling to continue. Allow cycling to continue for at least 2 hours to eliminate early problems.

TRANSITION EVENT CHART

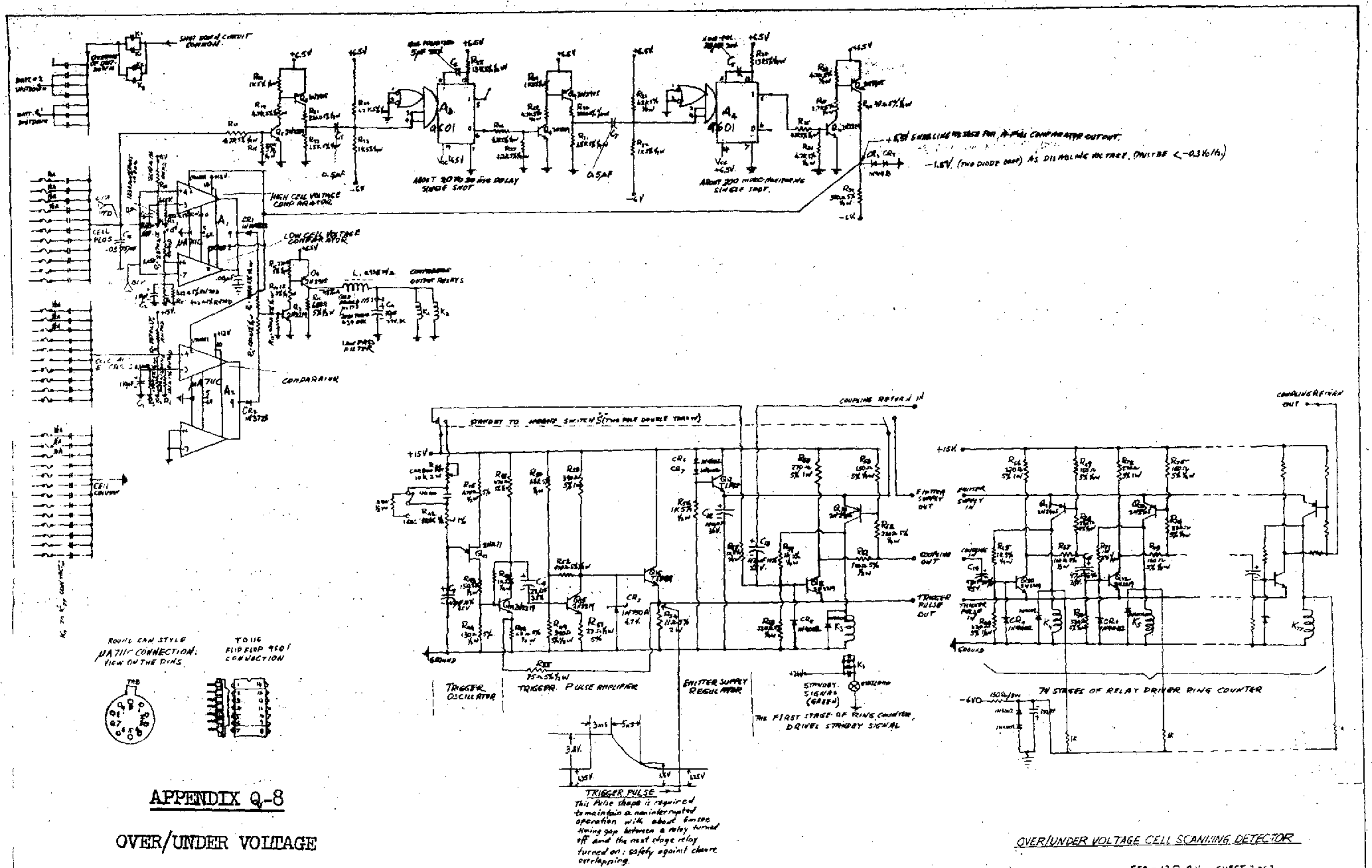




NOTES:

1. ALL RELAY SUPPRESSION CIRCUITS CONSIST OF 1N4148 DIODES, 0.01 µF CAPACITORS & 5% RESISTORS NEAREST IN VALUE TO COIL RESISTANCE.
2. ALL CONTACTOR SUPPRESSION CIRCUITS ARE AS FOLLOWS: DIODES = 1N4002; RESISTOR = 56Ω/2W; CAP = 0.1 µF

BOARD 7
MODE CONTROLLER

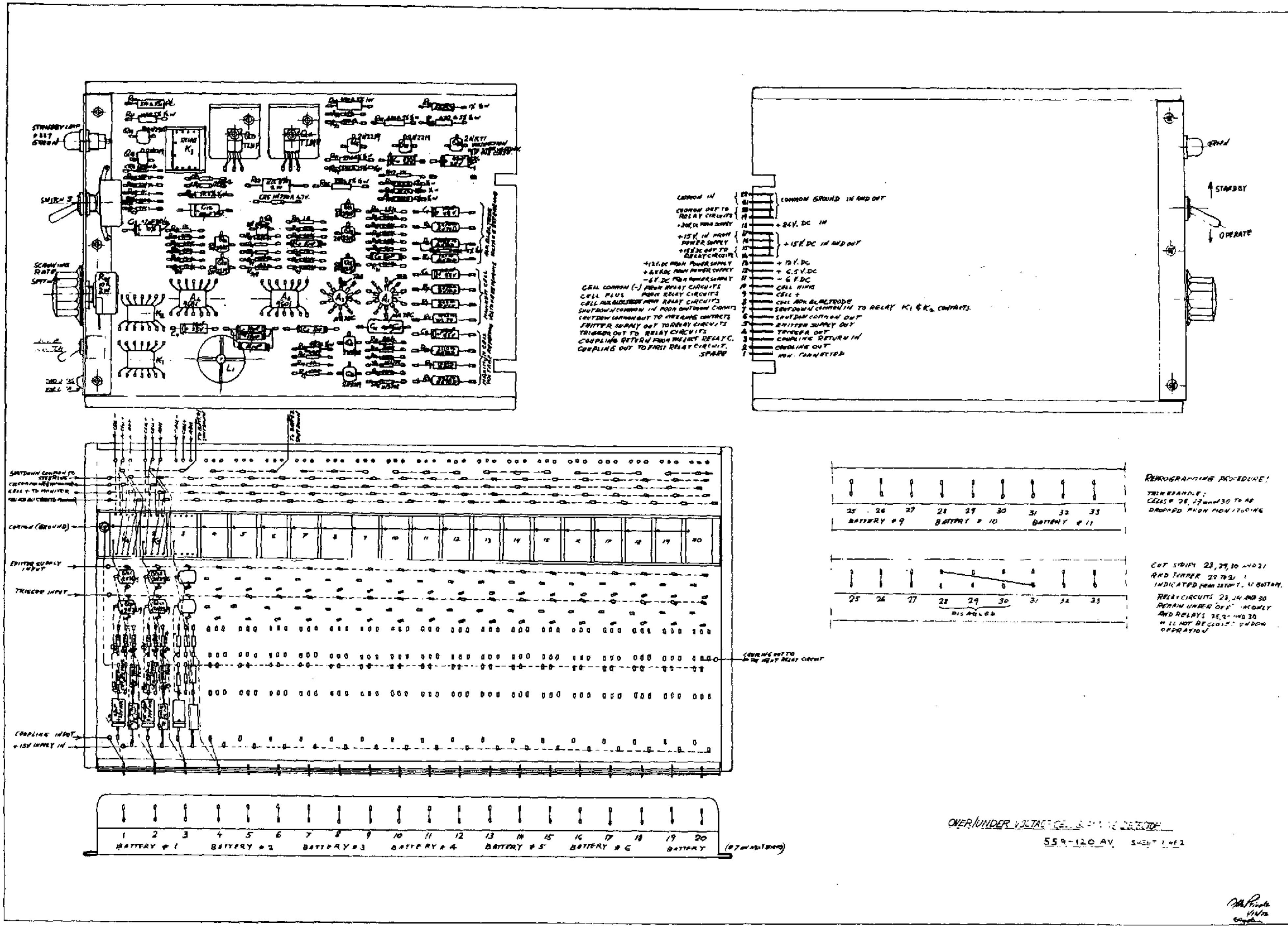


APPENDIX Q-8

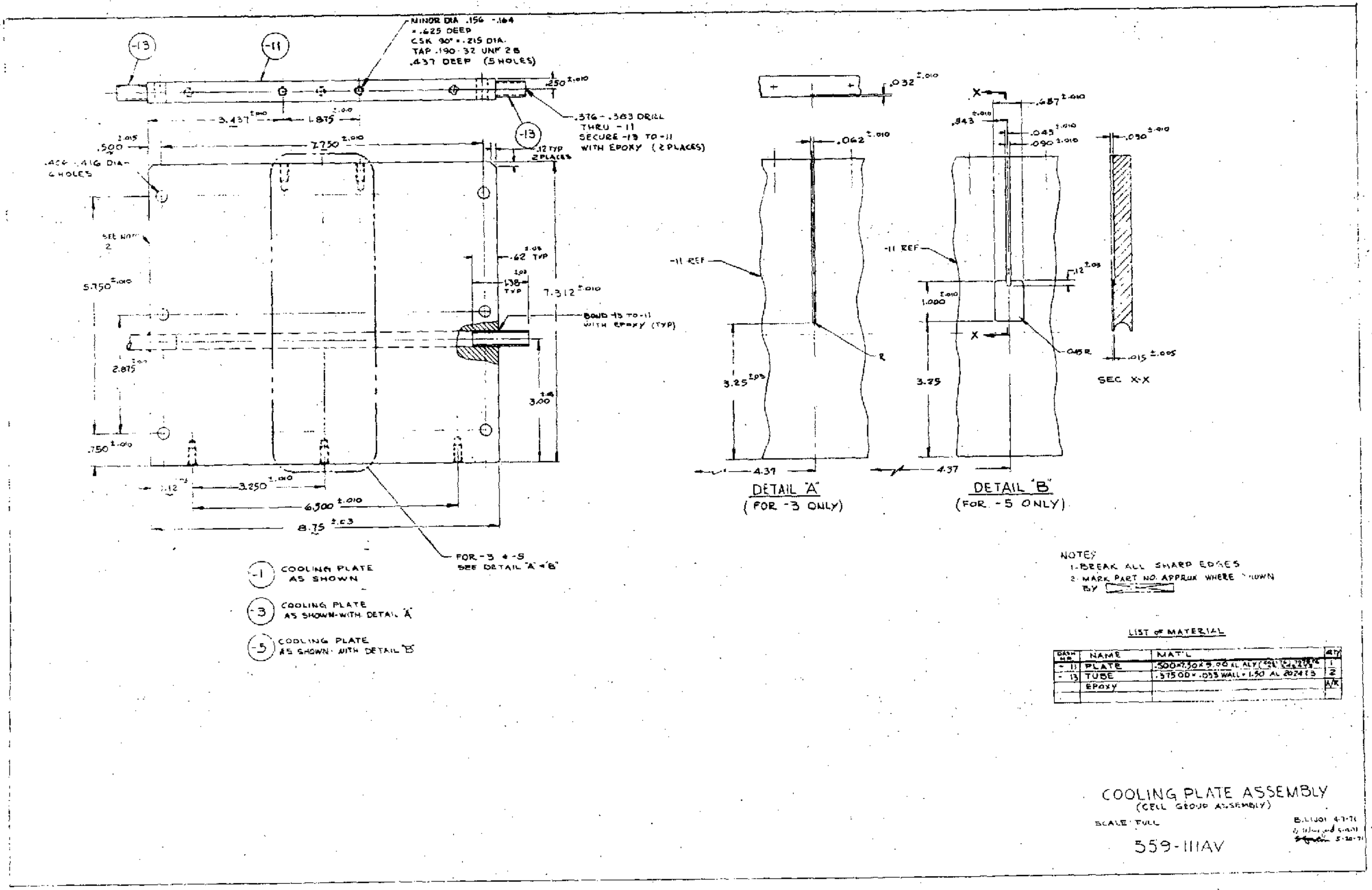
OVER/UNDER VOLTAGE

SCANNING DETECTOR

SCHEMATIC & LAYOUT



COMMON IN
COMMON GROUND IN AND OUT
+24V. DC IN
+15V. DC IN AND OUT
+12V. DC
+6.5V. DC
-6V. DC
CELL MINUS
CELL +
CELL AUX ELECTRODE
SHUTDOWN COMMON OUT
EMITTER SUPPLY OUT
TRIGGER OUT
COUPLING RETURN IN
COUPLING OUT
NON-CONNECTED
STANDBY
OPERATE
SWITCH
COMMON (GROUND)
TRIGGER INPUT
COUPLING INPUT
BATTERY # 1
BATTERY # 2
BATTERY # 3
BATTERY # 4
BATTERY # 5
BATTERY # 6
BATTERY # 9
BATTERY # 10
BATTERY # 11
DISABLED
REPROGRAMMING PROCEDURE!
OVER/UNDER VOLTAGE
559-120 AV

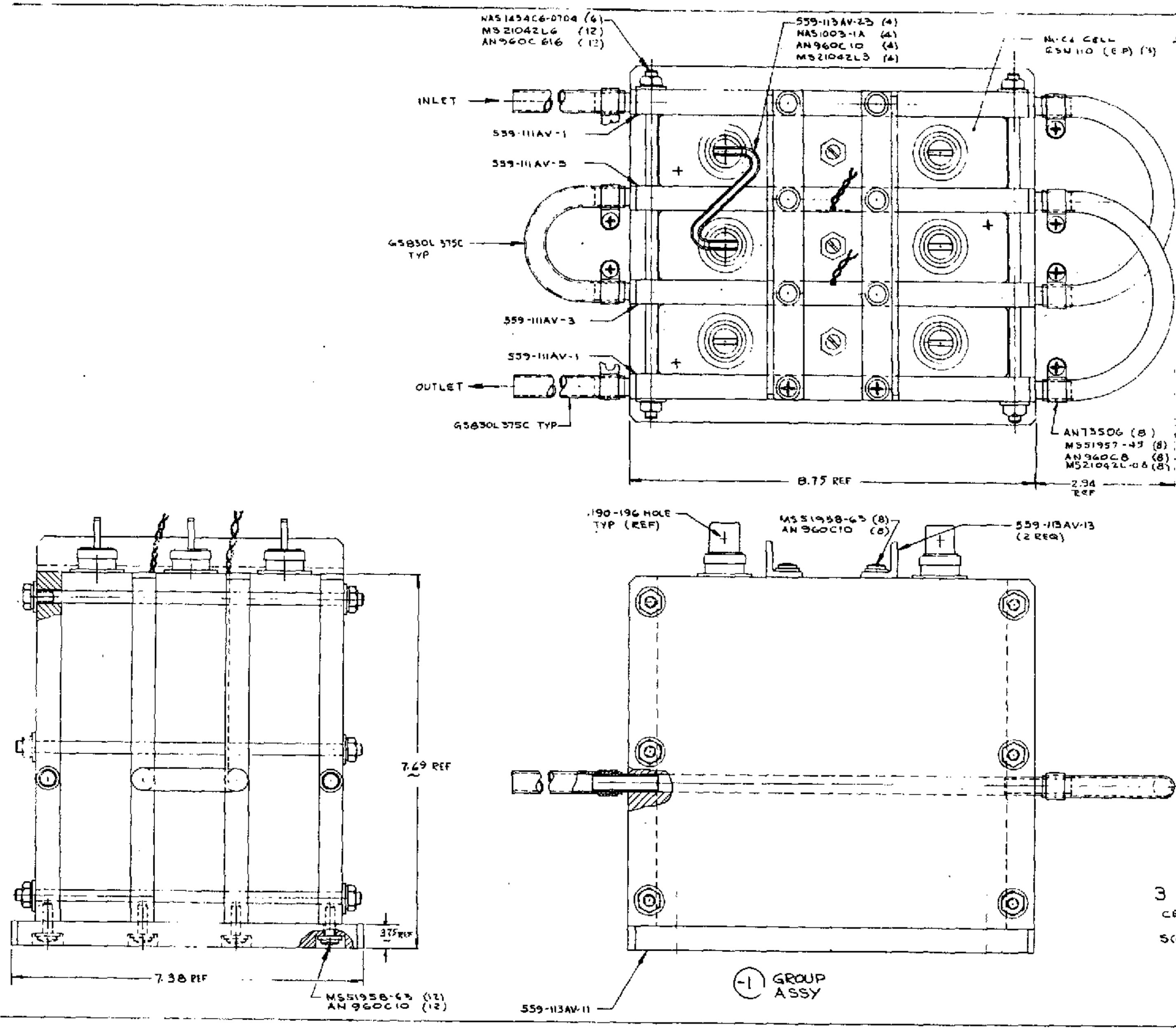


CELL STACK

APPENDIX Q-9

MECHANICAL

ASSEMBLIES



NOTES:
1. EACH CELL IS WRAPPED ALL AROUND EXCEPT TOP, IN ONE LAYER OF KAPTON FILM PRIOR TO ASSEMBLY
2. EACH CELL ARE FITTED WITH A COMPOUND S.S. STEEL PRESSURE GAUGE AND S.S. ADJUSTMENT VALVE (NOT SHOWN)

REQ	PART NO	NOMENCLATURE
6	GT82JP3[illegible]	KAPTON TAPE (1⅞ [illegible])
4	MS21042L3	#10-32 NUT
4	NAS1003-1A	#10-32 BOLT
3	EP-(GSN110)	CELL ASSY
2		BATTERY CABLE
1		SENSOR
1		THERMOCOUPLE
4	559-113-AV-23	CELL INTERCONNECTOR
8	AN960C8	WASHER #8
24	AN960C10	WASHER #10
12	AN960C616	WASHER-3/8
8	MS21042L-08	NUT 8-32
2	MS21042L6	NUT 3/8-24
8	MS51957-45	SCREW 8-32
20	MS51958-63	SCREW 10-32
8	AN735D6	CLAMP
6	NAS1454C6-0704	STUD
A/R	G5830L375C	TUBING
2	559-113AV-13	ANGLE
1	559-111AV-5	COOLING PLATE
1	559-111AV-3	COOLING PLATE
2	559-111AV-1	COOLING PLATE
1	559-113AV-11	BASE PLATE

PARTS LIST

GRUMMAN AEROSPACE

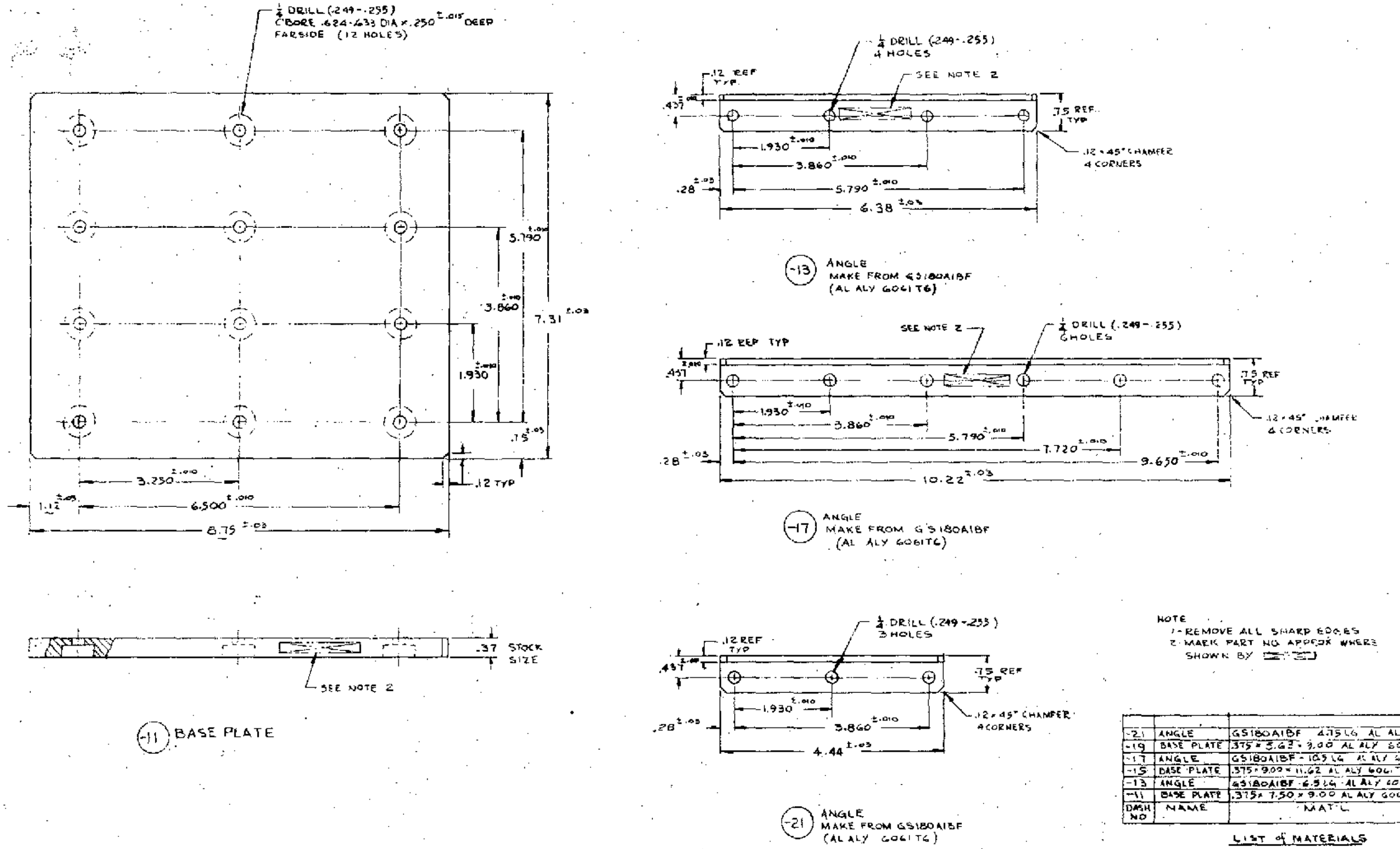
3 CELL GROUP ASSEMBLY

CELL CHARGER/PARAMETRICS TEST

SCALE FULL

[illegible] 3-18-71

559-112 AV



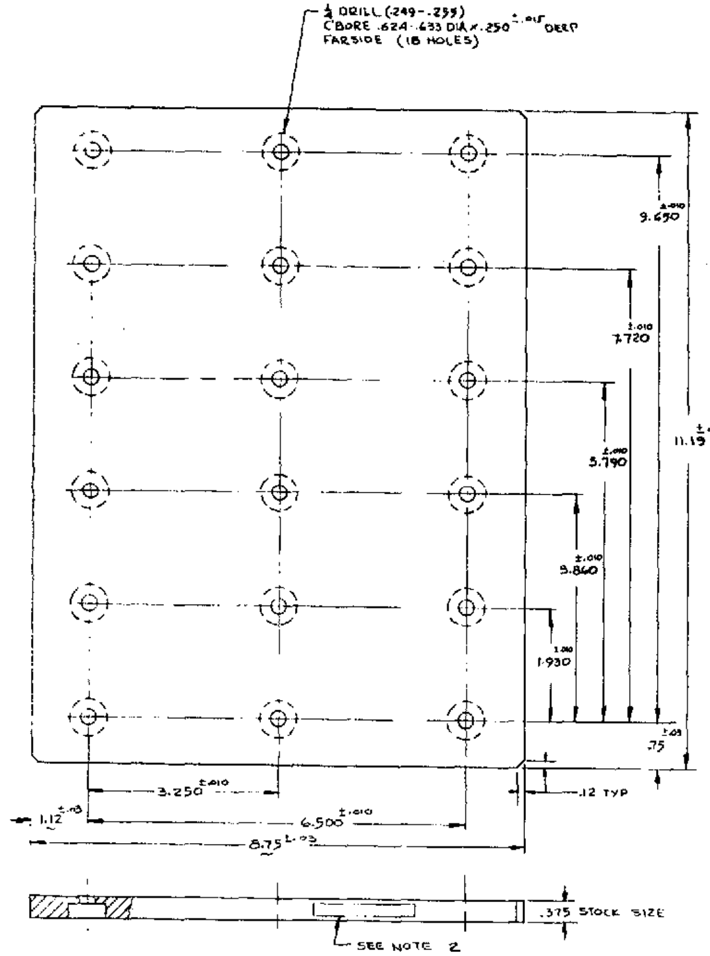
NOTE
1- REMOVE ALL SHARP EDGES
2- MARK PART NO APPROX WHERE SHOWN BY

-21	ANGLE	GS180A1BF 4.75 LG AL ALY 6061T6	2
-19	BASE PLATE	.375 x 5.62 x 9.00 AL ALY 6061T6	1
-17	ANGLE	GS180A1BF - 10.5 LG AL ALY 6061T6	2
-15	BASE PLATE	.375 x 9.00 x 11.62 AL ALY 6061T6	1
-13	ANGLE	GS180A1BF - 6.5 LG AL ALY 6061T6	2
-11	BASE PLATE	.375 x 7.50 x 9.00 AL ALY 6061T6	1
DASH NO	NAME	MAT'L	

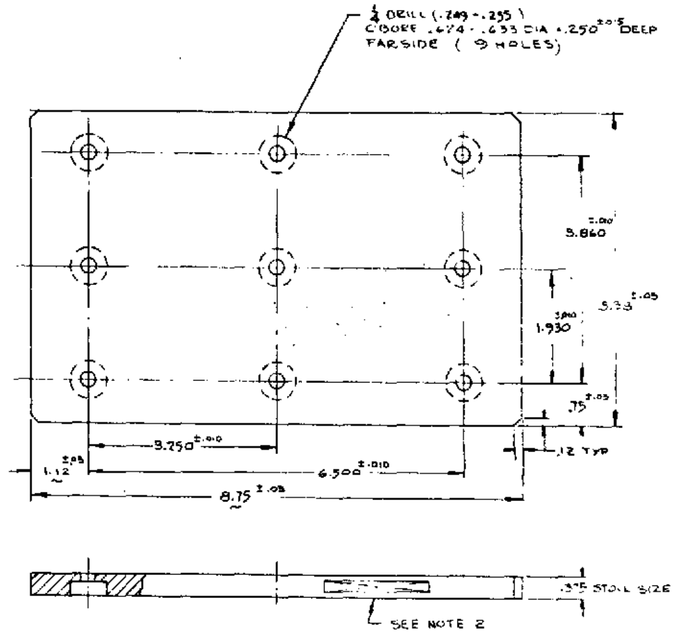
LIST of MATERIALS

MISC DETAILS
CELL GROUP ASSY
SCALE FULL

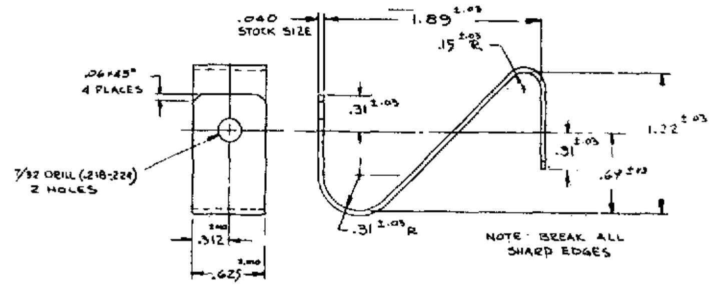
559-113AV
SHEET 1 of 2



(-15) BASE PLATE

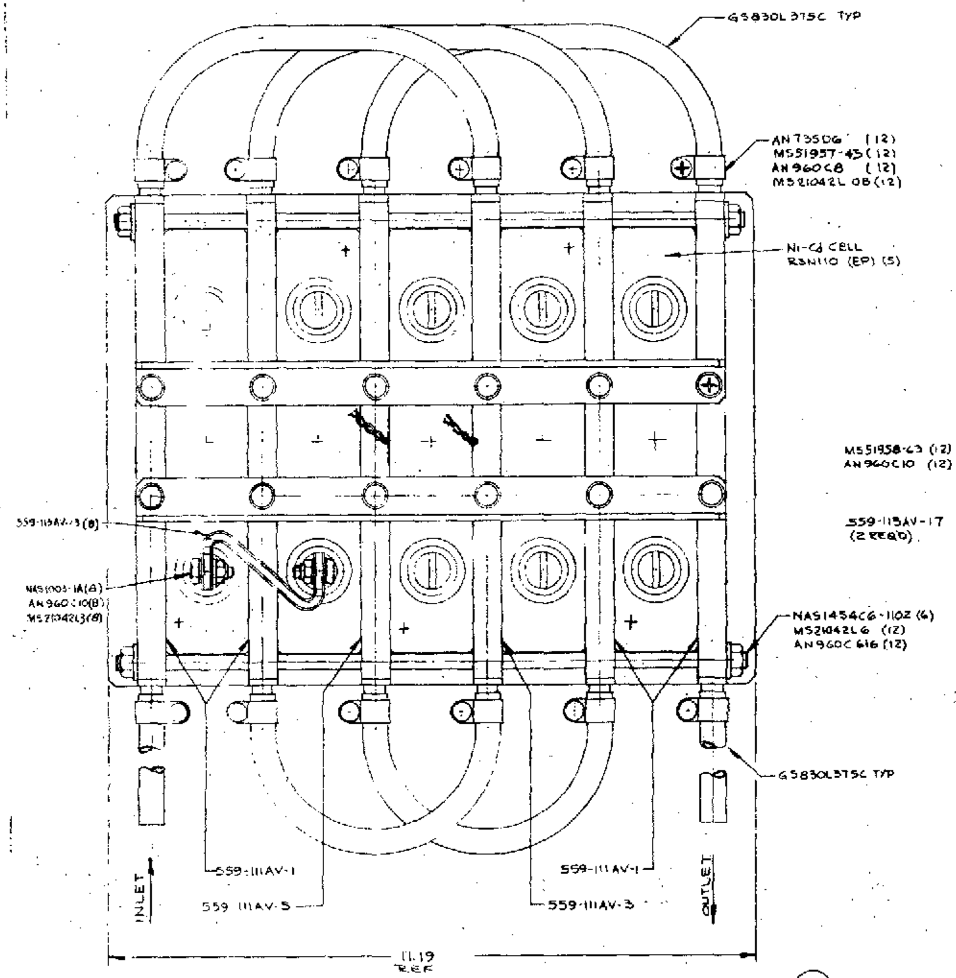


(-19) BASE PLATE

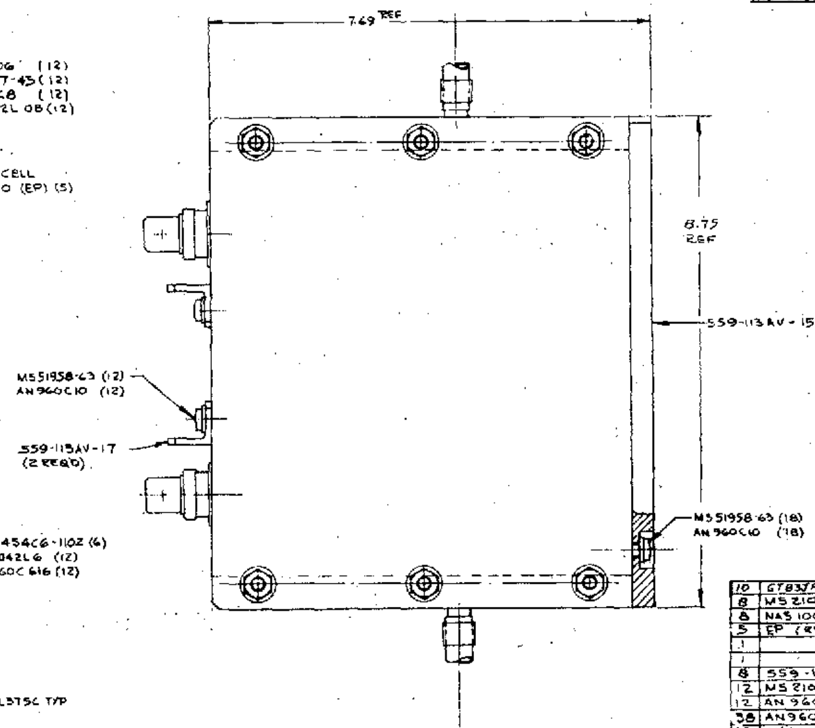


(-23) INTERCONNECTOR
MAKE FROM .040 THK
COPPER QQ-C-576 (HIGH CONDUCTIVITY)
NICKEL PLATE PER QQ-N-290 TYPE II
SCALE: 2/1

559-113AV
SHEET 2



(-1) GROUP ASSY



NOTES:

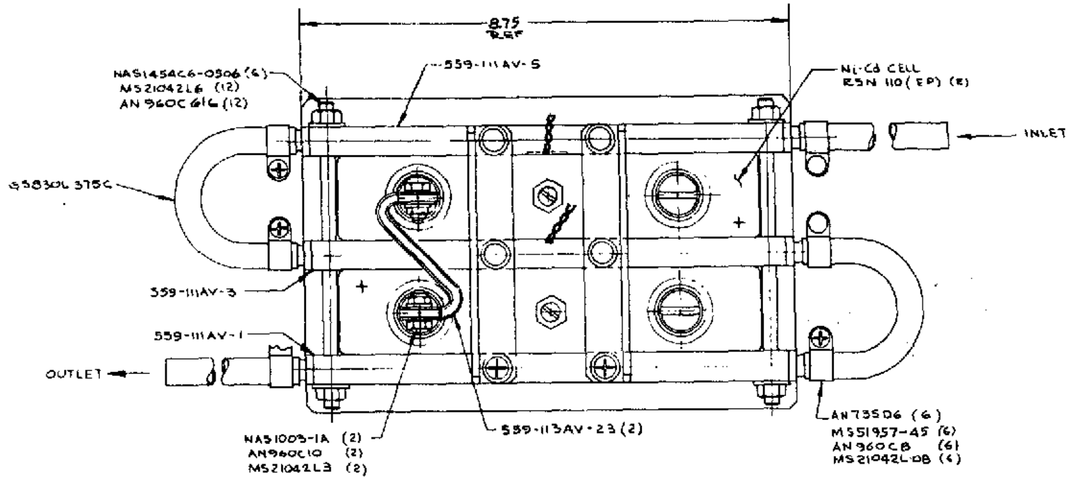
1. EACH CELL IS WRAPPED ALL AROUND EXCEPT TOP IN ONE LAYER OF KAPTON FILM PRIOR TO ASSEMBLY
2. EACH CELL IS RECEIVED WITH A COMPOUND S. S. PRESSURE GAUGE AND S.S. ADJUSMENT VALVE (NOT SHOWN)

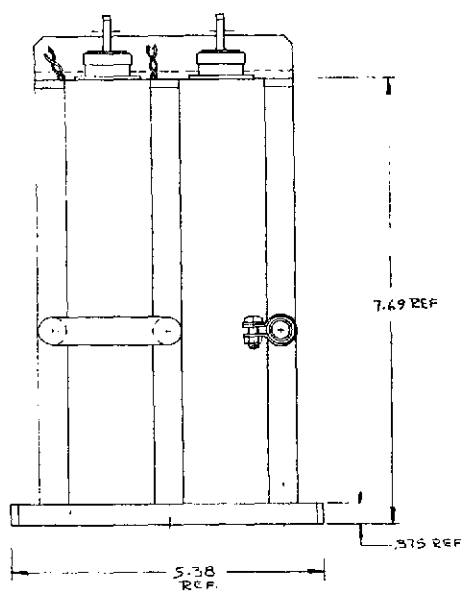
10	GT83JP32	KAPTON TAPE (1"/2"L)
8	MS21042L3	#10-32 NUT
8	NAS1003-1A	#10-32 BOLT
5	EP (RSN110)	CELL ASSY
1		SENSOR
1		THERMOCOUPLE
8	559-113AV-23	CELL INTERCONNECTOR
12	MS21042L6	NUT 3/8-24
12	AN960C8	WASHER #8
38	AN960C10	WASHER #10
12	AN960C616	WASHER (3/8)
30	MS51958-63	SCREW 10-32
12	AN735D6	CLAMP
12	MS21042L-08	NUT 8-32
12	MS51957-45	SCREW 8-32
6	NAS1454C6-1102	STUD
A/R	G5850L375C	TUBING
2	559-115AV-17	ANGLE
1	559-111AV-5	COOLING PLATE ASSY
1	559-111AV-3	COOLING PLATE ASSY
4	559-111AV-1	COOLING PLATE ASSY
1	559-113AV-15	BASE PLATE
REQ'D	PART NO	NOMENCLATURE

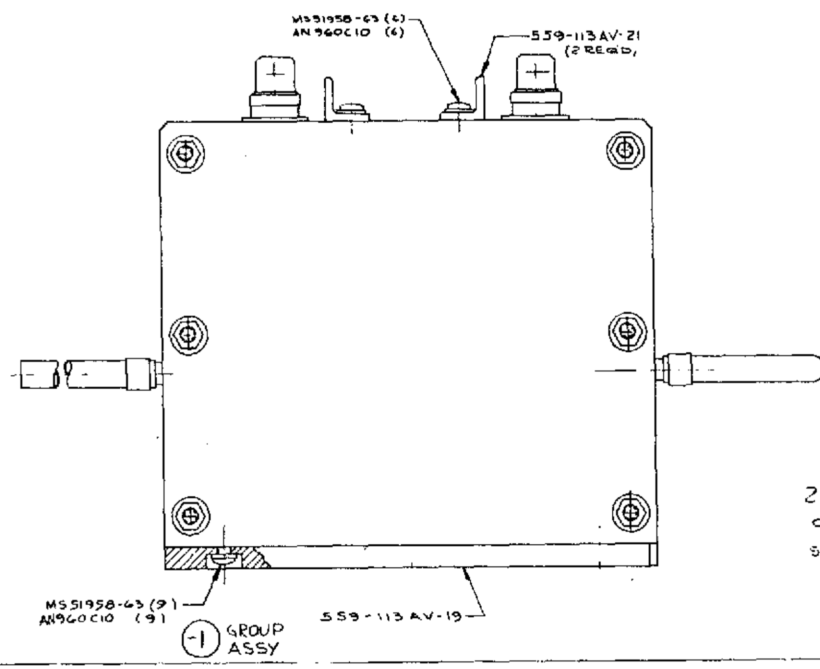
PARTS LIST

5 CELL GROUP ASSEMBLY
CELL CHARGER/PARAMETRICS TEST
SCALE: FULL

559-116AV







2	MS21042L3	#10-32 NUT
2	NAS1003-1A	#10-32 BOLT
2	EP- (RSN 110)	CELL ASSY
2		BATTERY CABLE
1		SENSOR
1		THERMO COUPLE
2	559-113AV-23	CELL INTERCONNECTOR
6	AN960C8	WASHER #8
17	AN960C10	WASHER #10
12	AN960C616	WASHER 3/8
6	MS21042L-08	NUT 8-32
12	MS21042L6	NUT 3/8-24
6	MS51957-45	SCREW 8-32
15	MS51958-63	SCREW 10-32
6	AN735D6	CLAMP
6	NAS1454C6-0506	STUD
A/R	GS830L375C	TUBING
2	559-113AV-21	ANGLE
1	559-111AV-5	COOLING PLATE ASSY
1	559-111AV-3	COOLING PLATE ASSY
1	559-111AV-1	COOLING PLATE ASSY
1	559-113AV-19	BASE PLATE
REQ	PART NO	NOMENCLATURE

PARTS LIST

2 CELL GROUP ASSEMBLY

CELL CHARGER/PARAMETRICS TEST

SCALE FULL

B. Lijol 4-27-71
G. Winger 5-12-71
[illegible] 5-20-71

559-117 AV

GRUMMAN AEROSPACE CORPORATION

PROJECT MEMORANDUM

D559-1-1

24 February 1971

DL 2/25/71

From: D. Lehrfeld, Thermodynamics - Ext. 9142

To: S. Gaston, POD - Ext. 9142

Subject: TEMPERATURE CONTROL DURING CELL/CHARGER PARAMETRIC AND CYCLE LIFE TESTING OF 100 AMPERE HOUR NiCd CELLS

References:
a) Contract NAS 9-11074
b) Test Program Plan, Rev. B, dated 21 January 1971, Contract NAS 9-11074

Summary

This memorandum discusses, and recommends the implementation of, a desireable method of temperature control which is suitable for adoption for the subject cell test programs. The method employs the use of combination restraining/cold plates and an actively circulating coolant medium. The advantages of this method over the simpler constant temperature immersion bath are discussed at length.

The details of the recommended mechanical restraint system for the test cells are presently under study and will be the subject of a subsequent memorandum.

Discussion

The cells to be evaluated in the subject test programs must be both mechanically restrained and thermally controlled while under test.

Mechanical restraint is required to provide the cells with the structural strength needed (and normally afforded packaged cells by the battery module case) to contain the high internal pressures which can be realized during overcharge. All six (6) sides of each cell will require restraint.

Thermal control is required since the subject tests specify that the effect of cell temperature on cell performance must be parametrically investigated (Reference b). Three (3) control temperatures have been selected; 0°C (32°F), 10°C (50°F) and 20°C (68°F). The reference cell temperature has been defined as the temperature of the broad face of the cell case at a point on a centerline between the terminals, three (3) inches from the bottom (See Figure 1). It is the dual function of the temperature control equipment to maintain the cells at these temperature levels and provide cooling in a manner which will yield intracell temperature gradients simulating those experienced by cells actually operated while packaged in battery modules.

In the opinion of the writer, the requisite cell temperature control can most effectively be achieved through the use of a constant temperature, circulating coolant system in conjunction with combination restraining/cold plates.

Figure 2 illustrates the recommended restraining/cold plate. Figure 3 shows how a typical three (3) cell test string would be grouped and cooled. As can be seen from these figures, it is recommended that the cold plates be connected in series with respect to the moving coolant rather than in parallel to prevent flow balancing problems. The flow rate would be made sufficiently large that the temperature rise in the direction of flow (and therefore cold plate to cold plate) would be negligible. (Additional cell strings could be added in series or parallel on the same coolant loop by making the flow rate large enough to accommodate the added heat load). The inlet coolant temperature would be held constant at the desired levels by a heat exchanger on the loop. The effluent fluid from the cold plates would exit into a bath surrounding the test string and flow around it back to the pump inlet. The purpose of the external bath is to minimize the thermal interchange that would otherwise occur between the laboratory ambient air and the test string. The heat generated by the test cells is transferred to the cold plates and from the plates into the coolant (in a manner very similar to the way they are cooled when packaged in a battery module).

The advantages of this temperature control system over a simple constant temperature liquid bath are:

a) the heat flow pattern from the test cells to the cooling medium closely approximates that found when cells are packaged into the Grumman battery module (therefore the intracell temperature gradients are the same),

b) this system permits restraining the cells broad side to broad side, a method which requires the least total volume,

c) each cell in the same control group receives equal cooling,

d) test strings can be wrapped to minimize cell wetting by the bath,

e) this system can be run closed loop (without a bath) by insulating the test string from the laboratory ambient air with polyurethane foam.

Tables 1 and 2 show the number of test strings and cells which constitute the subject tests. In addition, the required number of broad restraining plates (of the type shown in Figure 2) necessary for each test is shown.

It is Thermodynamics recommendation that this temperature control scheme be implemented and that the manufacturing department be contacted to determine the estimated cost of manufacturing the required restraining/cold plates. In addition, the remaining problem of how to restrain the four (4) narrow sides of the cell should be addressed as soon as possible to finalize the design of all the test hardware.

100 AH CELL REFERENCE TEMPERATURE LOCATION

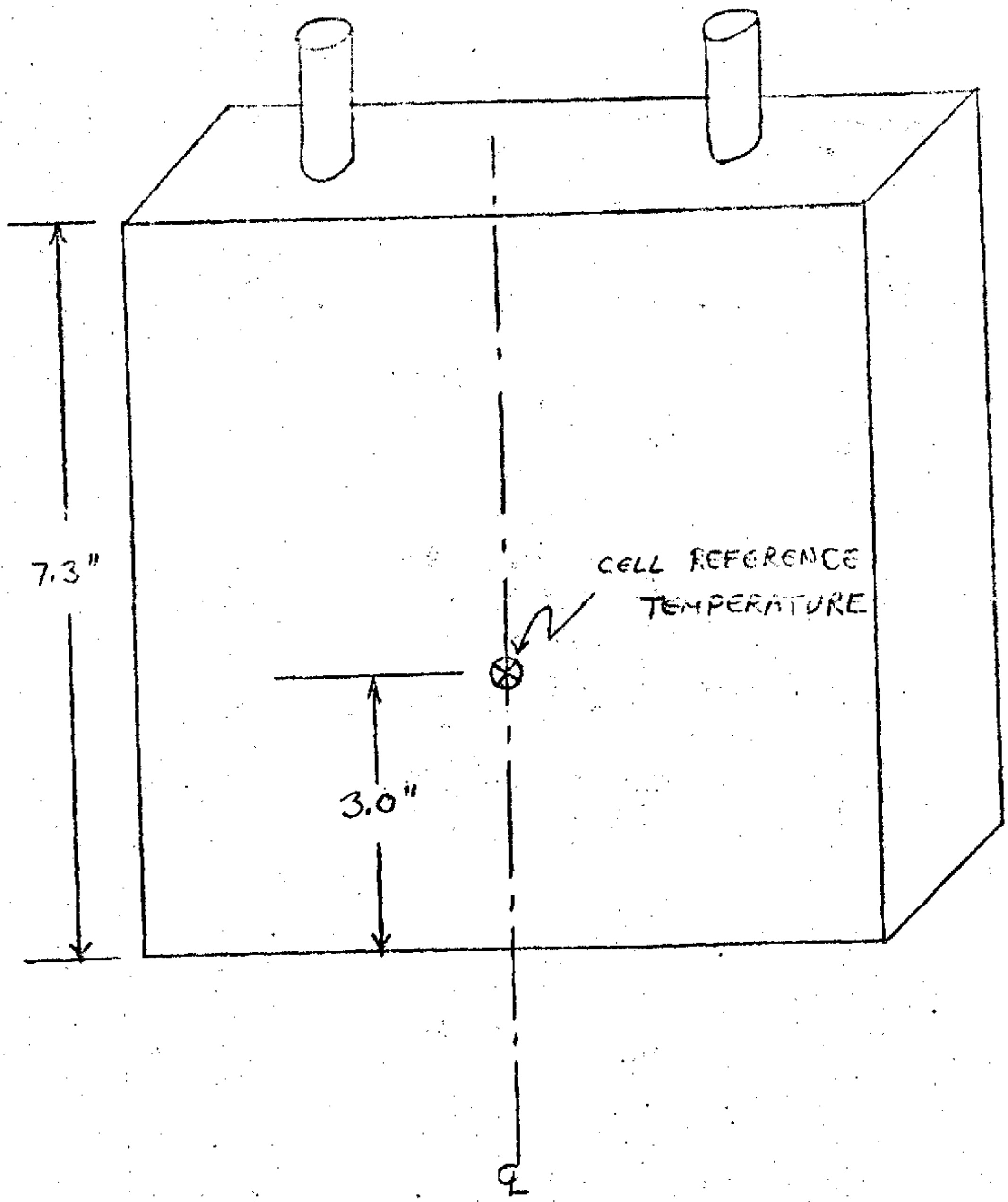


FIGURE 1

RESTRAINING/COLD PLATE

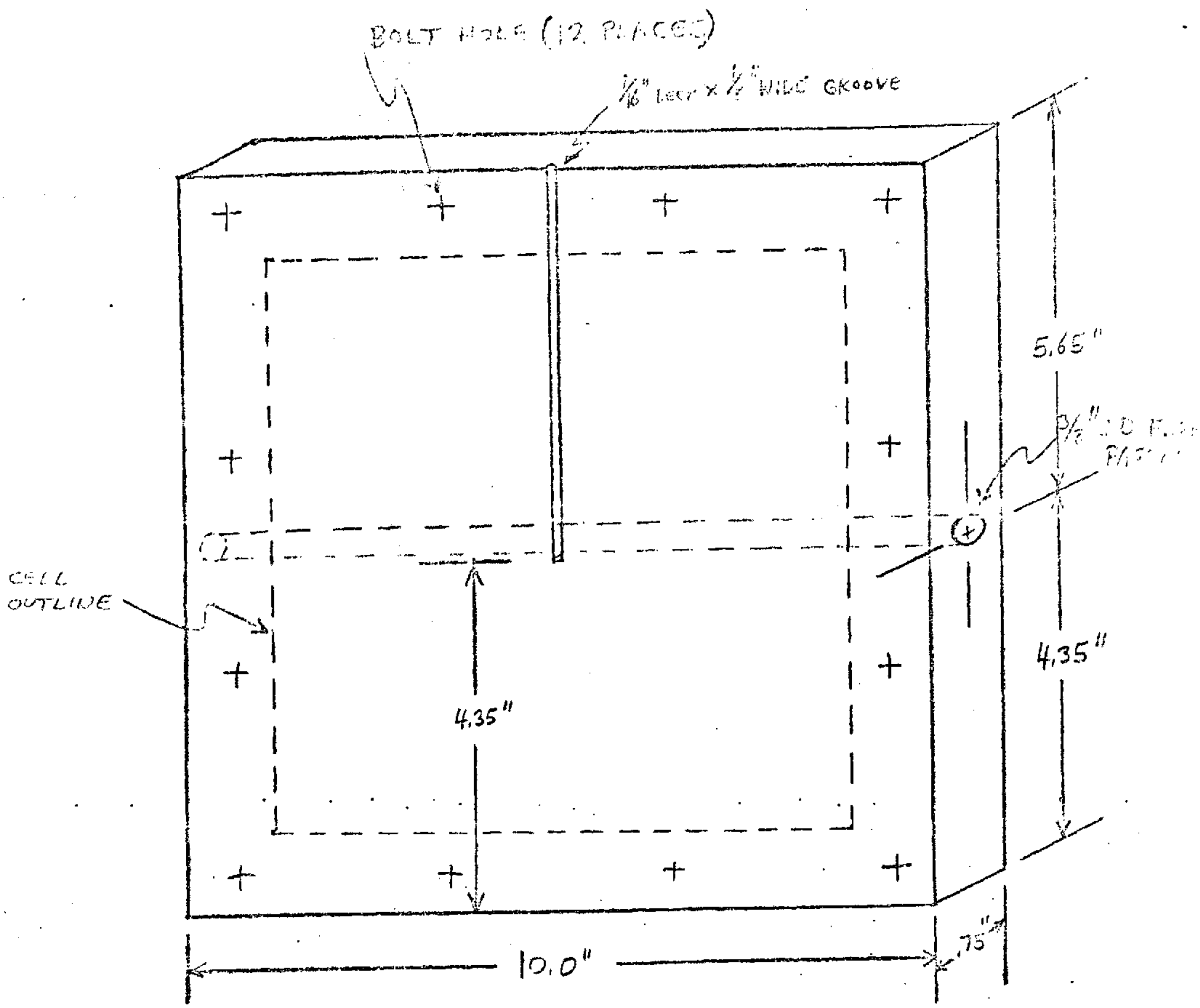
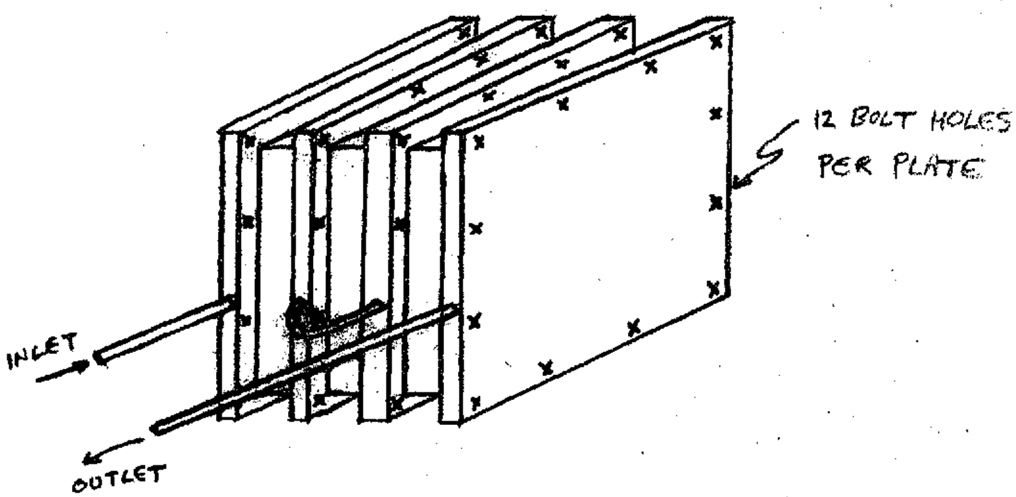


FIGURE 2

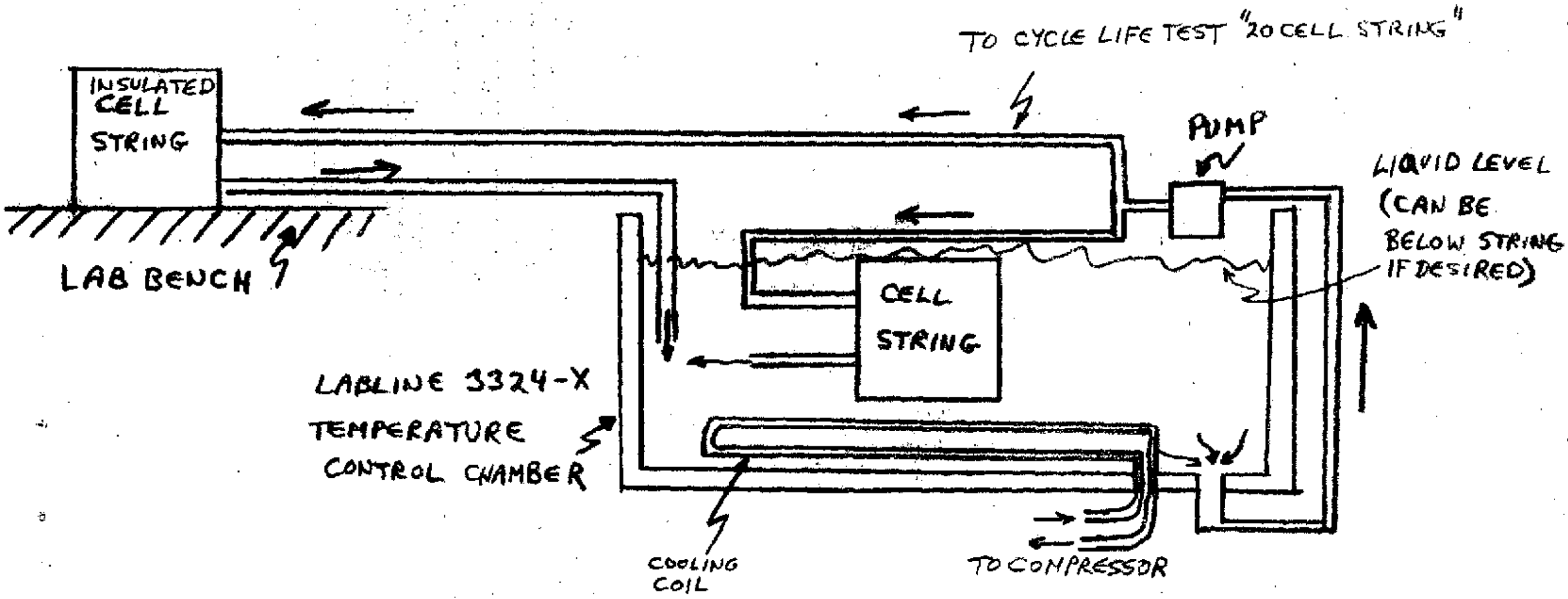
FIGURE 3

TYPICAL CELL STRING COOLING SYSTEM SETUP

CELL GROUPING:*



SYSTEM SETUP:



* FOUR NARROW SIDES OF EACH CELL WILL BE BOTH MECHANICALLY RESTRAINED FOR SAFETY AND THERMALLY INSULATED TO FORCE INTERNALLY GENERATED HEAT OUT THE BROAD FACES.

TABLE 1

Cell Charger/Parametrics Test

A) Total number cells: twenty seven (27)

(nine (9) - three (3) cell strings)

B) Control temperature/cell group arrangement:

T_1(0°C): four (4) - three (3) cell strings

T_2(10°C): two (2) - three (3) cell strings

T_3(20°C): three (3) - three (3) cell strings

C) Restraining plate requirements: thirty six (36) broad plates

(9 three cell strings x 4 plates per three cell string = 36 broad restraining plates)

TABLE 2

Cycle Life/Memory Effect and Stored Cell Tests

A) Total number cells: eighty five (85)

1. Stored cell tests: three (3) - two (2) cell strings, each @ 0°C and 25°C successively

2. Cycle life/memory effect tests:

   a) Thirteen (13) - three (3) cell strings,
   b) Two (2) - twenty (20) cell strings

B) Control temperature/cell group arrangement:

T_1(0°C): Five (5) - three (3) cell strings

T_2(10°C): Four (4) - three (3) cell strings

One (1) - twenty (20) cell string

T_3(20°C): Four (4) - three (3) cell strings

One (1) - twenty (20) cell string

C) Restraining plate requirements: one hundred and nine (109) broad plates

1. Stored cell tests:

   3 two cell groups x 3 plates per two cell group = 9 broad restraining plates

2. Cycle life/memory effect tests:

   a) 13 three cell strings x 4 plates per three cell string = 52 broad restraining plates

   b) 8* five cell groups x 6 plates per five cell group = 48 broad restraining plates

* each twenty (20) cell string composed of four (4)-five (5) cell groups.

ATTACHMENT 3

TYPICAL PRINTOUT - PARAMETRIC CYCLE DATA RECUTION PROGRAM

The following sheets show a typical printout of processed data from the Parametric Cycle Tests. The actual quantities shown are meaningless, since they were read from a sample data tape generated to debug and check the program, and containing purely arbitrary values.

The format is as follows:

1. Printout of preliminary data before start of orbital cycling -- verifies that data system is operating properly.
   a) Column 1 is channel ID
   b) Column 2 is reading in volts, millivolts, or microvolts
   c) Column 3 is a conversion to temperature in °F. For this part only, all readings are so converted to avoid extra, unnecessary instructions in program.
2. Selected dump of all data for one string. This also includes alarm data (string failure), and restoration to test time where applicable.
3. Summary of Orbital Cycling Statistics by orbit and string.
   a) Column 1 is titles and conditions
      1) I1 = 83.3 amp charge rate
      2) I2 = 50.0 amp charge rate
      3) I3 = 20.0 amp charge rate
      4) I4 = 5.0 amp charge rate
   b) Columns 2-4 are cell voltages
   c) Column 5 is Time
   d) Column 6 is Average Cell Temperature
   e) Column 7 is Temperature Sense Resistor Temperature
   f) Column 8 is Sum of Cell Volt
   g) Column 9 is Current
4. Plot of cell voltage versus time for the string selected for dump (2. above).

ORIGINAL COMPUTERIZED DATA REDUCTION/ ANALYSIS PROGRAM OUTPUT FOR IBM 360

FILE = FILE FT08F001 P10

0	******	******	320	******	******	53	******	******	54	0.0	32.000	55	0.0	32.000
55	0.0	32.000	57	0.0	32.000	58	0.0	32.000	59	0.0	32.000	60	0.0	32.000
61	0.0	32.000	62	0.0	32.000	63	0.0	32.000	64	0.0	32.000	65	0.000	32.005
55	0.0	32.000	67	0.0	32.000	68	0.0	32.000	69	0.0	32.000	70	0.0	32.000
71	0.0	32.000	72	0.0	32.000	73	0.0	32.000	74	0.0	32.000	75	0.0	32.000
76	0.0	32.000	77	0.0	32.000	78	0.0	32.000	79	0.0	32.000	80	0.0	32.000
81	0.0	32.000	82	0.0	32.000	83	0.0	32.000	84	0.0	32.000	85	0.0	32.000
86	0.0	32.000	87	0.0	32.000	88	0.0	32.000	89	0.0	32.000	90	0.0	32.000
91	0.0	32.000	92	0.0	32.000	93	0.0	32.000	94	0.0	32.000	95	0.0	32.000
95	0.0	32.000	97	0.0	32.000	98	0.0	32.000	99	0.0	32.000	100	0.0	32.000
101	0.0	32.000	102	1.348	92.699	103	1.348	92.699	104	1.348	92.699	105	1.348	92.699
106	1.348	92.699	107	1.348	92.703	108	1.348	92.703	109	1.348	92.703	110	1.348	92.699
111	0.0	32.000	112	0.0	32.000	113	0.000	32.002	114	0.000	32.002	115	0.000	32.002
115	0.000	32.002	117	0.000	32.002	118	0.000	32.002	119	0.000	32.002	120	0.000	32.002
121	0.000	32.002	123	0.0	32.000	124	0.0	32.000	125	1.348	92.699	126	0.013	32.629
127	0.000	32.000	128	0.0	32.000	129	0.000	32.000	130	0.0	32.000	131	0.000	32.000
132	0.000	32.000	133	0.000	32.000	134	0.000	32.000	135	0.0	32.000	136	0.0	32.000
137	0.000	32.000	138	0.000	32.000	139	0.000	32.000	140	0.000	32.000	141	0.000	32.000
142	0.000	32.000	143	0.000	32.000	144	0.000	32.000	145	0.0	32.000	146	0.000	32.000
147	0.000	32.000	148	0.000	32.000	149	0.0	32.000	150	0.000	32.000	151	0.0	32.000
152	0.000	32.000	153	0.000	32.000	154	0.000	32.000	155	0.000	32.000	156	0.000	32.000
157	0.000	32.000	158	0.0	32.000	159	0.000	32.000	160	0.000	32.000	161	0.000	32.000
162	0.0	32.000	163	0.0	32.000	164	0.000	32.000	165	0.000	32.000	166	0.000	32.000
167	******	******												
0	******	******	320	******	******	53	******	******	54	0.0	32.000	55	0.0	32.000
55	0.0	32.000	57	0.0	32.000	58	0.0	32.000	59	0.0	32.000	60	0.0	32.000
61	0.0	32.000	62	0.0	32.000	63	0.0	32.000	64	0.0	32.000	65	0.0	32.000
66	0.0	32.000	67	0.0	32.000	68	0.0	32.000	69	0.0	32.000	70	0.0	32.000
71	0.0	32.000	72	0.0	32.000	73	0.0	32.000	74	0.0	32.000	75	0.0	32.000
76	0.0	32.000	77	0.0	32.000	78	0.0	32.000	79	0.0	32.000	80	0.0	32.000
81	0.0	32.000	82	0.0	32.000	83	0.0	32.000	84	0.0	32.000	85	0.0	32.000
86	0.0	32.000	87	0.0	32.000	88	0.0	32.000	89	0.0	32.000	90	0.0	32.000
91	0.0	32.000	92	0.0	32.000	93	0.0	32.000	94	0.0	32.000	95	0.0	32.000
96	0.0	32.000	97	0.0	32.000	98	0.0	32.000	99	0.0	32.000	100	0.0	32.000
101	0.0	32.000	102	1.348	92.699	103	1.348	92.703	104	1.348	92.699	105	1.348	92.699
106	1.348	92.699	107	1.348	92.703	108	1.348	92.699	109	1.348	92.699	110	1.348	92.699
111	0.0	32.000	112	0.0	32.000	113	0.010	32.471	114	0.010	32.471	115	0.010	32.471
116	0.010	32.471	117	0.010	32.471	118	0.010	32.471	119	0.010	32.471	120	0.010	32.471
121	0.010	32.471	123	0.0	32.000	124	0.0	32.000	125	1.348	92.703	126	0.013	32.629
127	0.0	32.000	128	0.000	32.000	129	0.000	32.000	130	0.0	32.000	131	0.000	32.000
132	0.000	32.000	133	0.000	32.000	134	0.0	32.000	135	0.0	32.000	136	0.000	32.000
137	0.000	32.000	138	0.0	32.000	139	0.0	32.000	140	0.000	32.000	141	0.0	32.000
142	0.0	32.000	143	0.0	32.000	144	0.000	32.000	145	0.0	32.000	146	0.000	32.000
147	0.0	32.000	148	0.000	32.000	149	0.000	32.000	150	0.000	32.000	151	0.0	32.000
152	0.0	32.000	153	0.000	32.000	154	0.000	32.000	155	0.000	32.000	156	0.000	32.000
157	0.000	32.000	158	0.0	32.000	159	0.0	32.000	160	0.000	32.000	161	0.000	32.000
152	0.000	32.000	163	0.000	32.000	164	0.0	32.000	165	0.0	32.000	166	0.000	32.000
167	******	******												
0	******	******	320	******	******	53	******	******	54	0.0	32.000	55	0.0	32.000
55	0.0	32.000	57	0.0	32.000	58	0.0	32.000	59	0.0	32.000	60	0.0	32.000
61	0.0	32.000	62	0.0	32.000	63	0.0	32.000	64	0.0	32.000	65	0.0	32.000
66	0.0	32.000	67	0.0	32.000	68	0.0	32.000	69	0.0	32.000	70	0.0	32.000
71	0.0	32.000	72	0.0	32.000	73	0.0	32.000	74	0.0	32.000	75	0.0	32.000
76	0.0	32.000	77	0.000	32.005	78	0.0	32.000	79	0.0	32.000	80	0.0	32.000
81	0.0	32.000	82	0.0	32.000	83	0.0	32.000	84	0.0	32.000	85	0.0	32.000
86	0.0	32.000	87	0.0	32.000	88	0.0	32.000	89	0.0	32.000	90	0.0	32.000
91	0.0	32.000	92	0.0	32.000	93	0.0	32.000	94	0.0	32.000	95	0.0	32.000
96	0.0	32.000	97	0.0	32.000	98	0.0	32.000	99	0.0	32.000	100	0.0	32.000
101	0.0	32.000	102	1.348	92.699	103	1.348	92.699	104	1.348	92.699	105	1.348	92.703
106	1.348	92.699	107	1.348	92.703	108	1.348	92.699	109	1.348	92.703	110	1.348	92.699
111	0.0	32.000	112	0.0	32.000	113	0.025	33.170	114	0.025	33.170	[illegible]	0.025	33.170

635

II

115	0.025	33.17[illegible]	11[illegible]	[illegible]	33.17[illegible]	118	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
121	0.025	33.170	123	0.0	32.000	124	0.0	32.000	125	1.348	92.699	126	0.013	32.629
127	0.000	32.000	128	0.0	32.000	129	0.000	32.000	130	0.0	32.000	131	0.000	32.000
132	0.0	32.000	133	0.000	32.000	134	0.0	32.000	135	0.000	32.000	136	0.0	32.000
137	0.0	32.000	138	0.000	32.000	139	0.0	32.000	140	0.0	32.000	141	0.000	32.000
142	0.000	32.000	143	0.000	32.000	144	0.0	32.000	145	0.000	32.000	146	0.000	32.000
147	0.000	32.000	148	0.0	32.000	149	0.000	32.000	150	0.000	32.000	151	0.0	32.000
152	0.0	32.000	153	0.0	32.000	154	0.0	32.000	155	0.0	32.000	156	0.0	32.000
157	0.0	32.000	158	0.000	32.000	159	0.000	32.000	160	0.000	32.000	161	0.000	32.000
162	0.000	32.000	163	0.000	32.000	164	0.000	32.000	165	0.000	32.000	166	0.000	32.000
167	******	******												

```
**************************ALARM *************************

TRING    10 SHUTDOWN TIME =     110800
**************************ALARM *************************

TRING     7 SHUTDOWN TIME =     110800
**************************ALARM *************************

TRING     4 SHUTDOWN TIME =     110800
**************************ALARM *************************

TRING     2 SHUTDOWN TIME =     110800
**************************ALARM *************************

TRING     3 SHUTDOWN TIME =     110800

TIME =      110800
            0.0              1.34790          0.04016          32.00005
            0.0              1.34790          0.04016          32.00005
            0.0              1.34780          0.04016          32.00009

TIME =      110900
            0.0              1.34780          0.04015          32.00005
            0.0              1.34790          0.04015          32.00009
            0.0              1.34780          0.04015          32.00000

TIME =      111000
            0.0              1.34780          0.04015          32.00005
            0.0              1.34780          0.04015          32.00005
            0.0              1.34780          0.04015          32.00000

TIME =      111100
            0.0              1.34780          0.04015          32.00000
            0.00010          1.34790          0.04015          32.00005
            0.0              1.34770          0.04015          32.00009

TIME =      111200
            0.0              1.34780          0.04015          32.00000
            0.0              1.34790          0.04015          32.00005
            0.0              1.34780          0.04015          32.00000
```

637

TIME = 111300

0.0	1.34780	0.04015	32.00000
0.0	1.34780	0.04015	32.00006
0.0	1.34780	0.04015	32.00005

TIME = 111400

0.0	1.34780	0.04015	32.00005
0.0	1.34780	0.04015	32.00000
0.0	1.34780	0.04015	32.00009

TIME = 111500

0.0	1.34790	0.04015	32.00005
0.0	1.34780	0.04015	32.00005
0.0	1.34780	0.04015	32.00005

TIME = 111600

0.0	1.34780	0.04015	32.00000
0.0	1.34780	0.04015	32.00005
0.0	1.34790	0.04015	32.00000

TIME = 111700

0.0	1.34790	0.04015	32.00005
0.0	1.34780	0.04015	32.00005
0.0	1.34790	0.04015	32.00005

TIME = 111800

0.00010	1.34780	0.04015	32.00000
0.0	1.34790	0.04015	32.00000
0.0	1.34780	0.04015	32.00005

TIME = 111900

0.0	1.34780	0.04015	32.00000
0.0	1.34780	0.04015	32.00005
0.0	1.34780	0.04015	32.00005

TIME = 112000

0.0	1.34780	0.04015	32.00014
0.0	1.34770	0.04015	32.00005
0.0	1.34780	0.04015	32.00005

TIME = 112100

0.0	1.34780	0.04015	32.00005
0.0	1.34780	0.04015	32.00000
0.0	1.34780	0.04015	32.00000

TIME = 112200

0.0	1.34790	0.04015	32.00000

	0.0	1.34780	0.04015	32.00009
TIME =	112300			
	0.0	1.34790	0.04015	32.00000
	0.0	1.34780	0.04015	32.00005
	0.0	1.34790	0.04015	32.00005
TIME =	112400			
	0.0	1.34790	0.04015	32.00005
	0.0	1.34780	0.04015	32.00005
	0.0	1.34770	0.04015	32.00000
TIME =	112500			
	0.0	1.34790	0.04015	32.00000
	0.0	1.34790	0.04015	32.00000
	0.0	1.34780	0.04015	32.00005
TIME =	112600			
	0.0	1.34780	0.04015	32.00009
	0.0	1.34780	0.04015	32.00005
	0.0	1.34780	0.04015	32.00000
TIME =	112700			
	0.0	1.34780	0.04015	32.00005
	0.0	1.34780	0.04015	32.00009
	0.0	1.34780	0.04015	32.00009
TIME =	112800			
	0.0	1.34780	0.04015	32.00005
	0.0	1.34790	0.04015	32.00005
	0.0	1.34780	0.04015	32.00000
TIME =	112900			
	0.0	1.34780	0.04015	32.00000
	0.0	1.34780	0.04015	32.00005
	0.0	1.34780	0.04015	32.00000
TIME =	113000			
	0.0	1.34780	0.04015	32.00000
	0.0	1.34790	0.04015	32.00000
	0.0	1.34780	0.04015	32.00005
TIME =	113100			
	0.0	1.34790	0.04015	32.00005
	0.0	1.34780	0.04015	32.00009
	0.0	1.34780	0.04015	32.00005

TIME =	113200			
	0.0	1.34790	0.04015	32.00005
	0.0	1.34790	0.04015	32.00005
	0.0	1.34780	0.04015	32.00005
TIME =	113300			
	0.0	1.34780	0.04015	32.00000
	0.0	1.34780	0.04015	32.00005
	0.0	1.34780	0.04015	32.00005
TIME =	113400			
	0.0	1.34780	0.04015	32.00000
	0.0	1.34780	0.04015	32.00005
	0.0	1.34780	0.04015	32.00000
TIME =	113500			
	0.0	1.34790	0.02502	32.00005
	0.0	1.34780	0.02502	32.00005
	0.0	1.34780	0.02502	32.00009
TIME =	113600			
	0.0	1.34790	0.02502	32.00000
	0.0	1.34780	0.02502	32.00005
	0.0	1.34790	0.02502	32.00009
TIME =	113700			
	0.0	1.34780	0.02502	32.00000
	0.0	1.34780	0.02502	32.00005
	0.0	1.34780	0.02502	32.00005
TIME =	113800			
	0.0	1.34780	0.02502	32.00005
	0.0	1.34780	0.02502	32.00000
	0.0	1.34780	0.02502	32.00005
TIME =	113900			
	0.0	1.34780	0.01008	32.00000
	0.0	1.34790	0.01008	32.00005
	0.0	1.34780	0.01008	32.00000
TIME =	114000			
	0.0	1.34780	0.01007	32.00005
	0.00010	1.34780	0.01007	32.00005
	0.0	1.34780	0.01007	32.00000
TIME =	114100			

	0.0	1.34780	0.00502	32.00000
	0.0	1.34780	0.00502	32.00009
TIME =	114200			
	0.0	1.34780	0.00206	32.00005
	0.0	1.34780	0.00206	32.00000
	0.0	1.34790	0.00206	32.00000
TIME =	114300			
	0.0	1.34790	0.00206	32.00000
	0.0	1.34780	0.00206	32.00000
	0.0	1.34780	0.00206	32.00000
TIME =	114400			
	0.0	1.34790	0.00206	32.00000
	0.0	1.34780	0.00206	32.00005
	0.0	1.34780	0.00206	32.00005
TIME =	114500			
	0.0	1.34790	0.04014	32.00000
	0.0	1.34780	0.04014	32.00000
	0.0	1.34780	0.04014	32.00000

PARAMETERIC TEST RESULTS FOLLCW

TEST DATE 32? STATISTICS FCR CREIT NUMBER 1

STRING NUMBER 1

DISCHARGE	C1	C2	C3	TIME	ACT	TSR	SCV	AMP
VOLT START	0.0	0.0	C.0	110700.	32.000	32.000	0.0	80.316
AUX START	0.0	0.C	0.0	C.	0.0	0.0	0.0	0.0
VOLT END DCH	0.0	0.0	C.0	112900.	32.000	32.000	C.0	80.300
AUX END DCH	0.0	0.0	C.0	0.	0.0	0.0	0.0	0.0
CHARGE								
VOLT ST I1	0.0	0.0	0.0	113000.	32.000	32.000	C.0	80.302
VOLT END I1	0.0	0.0	0.0	113400.	32.000	32.000	0.0	80.304
VOLT ST I2	0.0	0.0	C.0	113500.	32.000	32.000	C.0	50.050
VOLT END I2	0.0	0.0	0.0	113800.	32.000	32.000	0.0	50.050
VOLT ST I3	0.0	0.0	C.000	113900.	32.000	32.000	C.300	20.154
VOLT END I3	0.0	C.C	0.0	114100.	32.000	32.000	0.0	10.046
VOLT ST I4	0.0	0.0	0.0	114200.	32.000	32.000	0.0	4.114
VOLT END I4	0.0	0.0	C.0	114400.	32.000	32.000	0.0	4.114
	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I1	0.0	0.C	0.0	0.	0.0	0.0	0.0	0.0
AUX END I1	0.0	0.C	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I2	0.0	0.C	0.0	0.	0.0	0.0	0.0	0.0
AUX END I2	0.0	C.C	C.0	0.	0.0	0.0	0.0	0.0
AUX ST I3	0.0	C.C	0.0	0.	0.0	0.0	0.0	0.0
AUX END I3	0.0	0.0	C.0	0.	0.0	0.0	C.0	0.0
AUX ST I4	0.0	0.C	0.0	0.	0.0	0.0	0.0	0.0
AUX END I4	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0

VIII

TEST DATE 320 STATISTICS FOR ORBIT NUMBER 1

STRING NUMBER 2

****

ALARM CONDITION EXIST

DISCHARGE	C1	C2	C3	TIME	ACT	TSR	SCV	AMP
VOLT START	0.0	0.0	0.0	110700.	32.000	32.000	0.0	80.314
AUX START	0.000	0.0	0.0	0.	0.0	0.0	0.000	0.0
VOLT END DCH	0.0	0.0	0.0	112900.	32.000	32.000	0.0	80.300
AUX END DCH	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
CHARGE								
VOLT ST I1	0.0	0.0	0.0	113000.	32.000	32.000	0.0	80.302
VOLT END I1	0.0	0.0	0.0	113400.	32.000	32.000	0.0	80.306
VOLT ST I2	0.0	0.0	0.0	113500.	32.000	32.000	0.0	50.048
VOLT END I2	0.0	0.0	0.0	113800.	32.000	32.000	0.0	50.048
VOLT ST I3	0.0	0.0	0.0	113900.	32.000	32.000	0.0	20.152
VOLT END I3	0.0	0.0	0.0	114100.	32.000	32.000	0.0	10.044
VOLT ST I4	0.0	0.0	0.0	114200.	32.000	32.000	0.0	4.114
VOLT END I4	0.0	0.0	0.0	114400.	32.000	32.000	0.0	4.114
	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I1	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX END I1	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I2	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX END I2	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I3	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX END I3	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I4	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX END I4	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0

WATT-HOURS OUT	WATT HOURS IN	PER RETURN
0.02008	-0.01905	-94.87683

AMP-HOURS OUT	AMP-HOURS IN	PER RETURN
32.12134	10.36974	32.28300

	WATT-HOURS OUT	WATT HOURS IN	PER RETURN
4	0.07702357	0.02433703	31.59686279
5	0.07695669	0.02433721	31.62452698
6	0.07702303	0.02433713	31.59718323

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II

TEST DATE 320 STATISTICS FOR ORBIT NUMBER 1

STRING NUMBER 3

****

ALARM CONDITION EXIST

DISCHARGE	C1	C2	C3	TIME	ACT	TSR	SCV	AMP
VOLT START	0.0	0.0	0.0	110700.	32.000	32.000	0.0	80.316
AUX START	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
VOLT END DCH	0.000	0.0	0.0	112900.	32.000	32.000	0.000	80.302
AUX END DCH	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
CHARGE								
VOLT ST I1	0.0	0.0	0.0	113000.	32.000	32.000	0.0	80.302
VOLT END I1	0.0	0.0	0.0	113400.	32.000	32.000	0.0	80.304
VOLT ST I2	0.0	0.0	0.0	113500.	32.000	32.000	0.0	50.048
VOLT END I2	0.0	0.0	0.0	113800.	32.000	32.000	0.0	50.048
VOLT ST I3	0.0	0.0	0.0	113900.	32.000	32.000	0.0	20.154
VOLT END I3	0.0	0.0	0.0	114100.	32.000	32.000	0.0	10.044
VOLT ST I4	0.0	0.0	0.0	114200.	32.000	32.000	0.0	4.114
VOLT END I4	0.0	0.0	0.0	114400.	32.000	32.000	0.0	4.114
	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I1	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX END I1	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I2	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX END I2	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I3	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX END I3	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX ST I4	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0
AUX END I4	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0

WATT-HOURS OUT	WATT HOURS IN	PER RETURN
0.02014	-0.01911	-94.89449

AMP-HOURS OUT	AMP-HOURS IN	PER RETURN
32.12143	10.36980	32.28310

	WATT-HOURS OUT	WATT HOURS IN	PER RETURN
7	0.07709068	0.02433689	31.56916809
8	0.07702321	0.02433668	31.59654236
9	0.07702339	0.02437841	31.65065002

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GRUMMAN AEROSPACE CORPORATION

AVOID VERBAL ORDERS

APPENDIX Q-12

APPENDIX Q-12

COMPUTER PROGRAM REVISIONS

FROM: L. Pessin | 553/POD | 35 | 9142 — DATE 5/1/72

NAME | GROUP NO. & NAME | PLANT NO. | EXT.

NO. D559-2-20

TO:
S. Gaston
R. Lutz
R. Quinn

SUBJECT: 100 A-H TEST DATA REDUCTION - COMPUTER PROGRAM REVISION

Reference: a). NASA/MSC Contract NAS 9-11074

The following tasks are to be performed in order to make the analysis of battery data more efficient and complete. Please provide time estimate.

Task 1

Change program such that channel vs. test point variable is read in on input cards. Print out all card input data.

Task 2

In the orbit statistics listing change following:

1. Print only active strings.
2. If orbit does not follow expected pattern of discharge 80 amp, 50 amp, 20 amp, and 5 amp charging print a message indicating this fact.
3. Include pressure readings in the orbit statistics listing (where applicable).
4. At beginning of listing print out channels and test point description. E.g.: V01S11-075 would describe the voltage of cell number 1 in string 11 being on channel 75.

Task 3

Store following on a tape or disc for listing:

1. Message generated by Item 2, Task 2 above.
2. A string shutdown.
3. % amp-hour return drops below 102% and % watt-hour return drops below 115%. (In place of a separate amp-hour summary)
Identify each message by Julian day, orbit number, and string number.

Task 4

Make the following plots for selected orbits. The max. column is the maximum number of graphs needed in the Life Test.

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ITEM	MAX.	INPUT RANGE	TRANSLATE TO
Cell voltage	67	.9 to 2.00 V	--
String current	15	0 to 50 MV	0 to 100A
String temperature	19	-.04 to +.83 MV	30 to 70°F
Aux. volts	9	0 to 1.0 V	--
Gage pressure	5	-.8 to 2.0 MV	--

Where possible plot up to 3 graphs/plot, with cell voltages and string current on same plot, temperatures for a string on same plot etc.

Task 5

The program computer shall be capable of operating with a battery test data tape of the following characteristics: 7 track, no label, fixed record format, logical record equal to 12 bytes*, physical record size (block size) dependent on number of channels in use (for amp test this is 12 x 76 or 912 bytes), and 1 to 4 files. The tape will contain either approximately three or approximately four days of test data. In each physical record the first data word indicates the orbit time, the second data word, called the manual data word, contains the Julian day and string alarms which will indicate any string shutdowns. The 72nd word indicates discharge or charge. The end of a tape is indicated by the Julian day having a value > 400.

The paper label affixed to the tape will indicate the following

Tape Number________ Number of Files________

File__ Julian Date________ Orbit Number Beginning________ Ending________

File__ Julian Date________ Orbit Number Beginning________ Ending________

The beginning and ending orbit numbers shall be assigned to the listings and plots obtained from that file.

If the Julian date changes but is less than 400 while processing a tape this signals the start of a new test. The end of a test is indicated by inserting a tape mark.

* IBM bytes

Task 6

Discharge Integration - The discharge current shall be integrated from the first discharge reading to the last discharge reading plus 1/3 minutes times the first discharge reading and 2/3 minutes times the last discharge reading.

Charge Integration - A voltage limit vs. temperature data shall be added as input cards. The charge integration will have 1/3 minute times the first charge reading plus 2/3 minutes times the last charge reading added. At each charge current step change the time within the one minute interval at which the current changes will be determined as follows:

$$\Delta t = (V_{LIM} - V_2)/(V_2 - V_1)$$

= Switchover interval from last readings

V_{LIM} = Voltage limit

V_2 = Last string voltage reading

V_1 = Next-to-last reading

If $\Delta t < 1.0$ and switching has occurred the current integration shall use Δt instead of one minute during the switchdown interval. The remaining integrations will use the method already in the program.

Task 7

Compute watt-hours (heat) and printout on orbit statistics listing. Compute as follows:

$$Q = W\ C_p\ \Delta T/3.415$$

Q = Heat in watts

W = Flow rate lbs./hour (defined on input card)

C_p = Sp. heat of H_2O in BTU/lb./^0C $\doteq$ 1.0

ΔT = Outlet-inlet temp. in ^oF

Sum Q times time for the orbit to yield watt-hours (heat).

Task 8

For strings longer than 3 cells, determine and print out on orbit statistics listing the cells which have the lowest, highest and average values. The average cell voltage can be obtained from the string voltage.

INFO cc:
D. Crowley
T. Hine
E. Miller
R. Sablich
M. Wertheim

AVOID VERBAL ORDERS

FROM M. Wertheim — 553/POD — 35 — 84212 — DATE 6/8/72

NAME — GROUP NO. & NAME — PLANT NO. — EXT. — NO. D559-2-26

TO: L. Pessin, V. Falcone, J. Gambale

SUBJECT: AGREEMENTS FROM MEETING OF 6/5/72 AND RESULTING ACTION

Reference: a) Contract No. NAS 9-11074

AGREEMENTS

At the subject meeting between M. Wertheim and L. Pessin (S. Gaston attending part-time) the following was agreed upon with respect to the data reduction programs for parametric and life cycle testing:

1. Each data tape will contain up to four (4) days' data.
2. For each file (one test condition), the program will examine the first data record on the tape for comparison with the inputted format. If the data format does not match the input format, the program will automatically stop. The input format may be changed by replacement of the appropriate input format card.
3. All subsequent records (data scans) up to that containing the first discharge flag will also be printed out.
4. The program will allow use of three (3) discharge flags, any one of which may be used to provide valid program instruction. Generally the first channel number will be used, unless otherwise specified by test personnel. However, the program will contain fault testing for the flag. Test personnel will provide the information on which data words contain the flags.
5. The program will show all anomalies in the orbital statistics printout. In addition, a separate summary listing will be provided of all anomalies. Until further notice, the low limits for return will be:

   115% for watt-hours
   102% for ampere-hours.

6. The program will be structured to permit application of charge voltage-temperature limits (for integration purposes) on a per string basis. Data for each string will be provided by test personnel in the form of two specific voltage-temperature points.
7. The program will also be geared to utilize flow rate data on a per string basis. Flow rates and corrections for ambient effects on inlet and outlet temperatures will be supplied by test personnel as input data.
8. In order to provide for proper orbit counting, and to allow reduction of all valid data, test personnel shall make test condition changes when using the same tape as follows:

   a) Allow orbit to complete and transfer to discharge.
   b) Following first discharge scan, shut down main, bias, logic and timing power.
   c) Enter file gap and stop tape.

d) Change Julian date by 1 day before restarting.
e) Restart in normal sequence after changing test condition and restarting tape.

There shall be a maximum of four (4) files (test conditions) per tape.

9. When changing tape, test personnel shall end tape in accordance with previous instructions. When tape is changed during a single test condition (e.g.: 200-orbit burn-in, life cycle tests), the change shall be made during the charge portion of an orbit in such a fashion that the initial data on the new tape shall be that for the remainder of that charge. Such tapes shall consist, generally, of one file.
10. Each tape shall be marked with the following information for each file on that tape:

    a) Start orbit number
    b) Orbit number of last fully recorded orbit.

    Project personnel shall convert this into input data before submission for reduction.
11. L. Pessin shall investigate various methods of storing recorded test data based on cost, volume and availability.
12. Plotted data shall include the following on a per orbit basis for each string -- all vs. time:

    a) Cell voltage
    b) Auxiliary voltage where applicable
    c) Pressure millivolts where applicable
    d) TSR temperatures
    e) Thermal dissipation/minute

S. J. Gaston, Project Engineer

INFO cc:

T. Hine
R. Lutz
E. Miller
R. Quinn

```
SEQUENCE,1,GET SOURCE DECKS FOR MOD AND ORBPLOT                  ** MSOS V4.2 EDITION=AC DATE=07/13/73 TIME=12.
JOB,SYSTEM,,,,,,
FET,COSY,APPLICATIONS,512
OPEN,1,1
EQUIP,2=MTCSE0U00
COSY,N,S
REWIND,2
FORTRAN,I=2,L,W

                    MS FORTRAN (4.2)/MSOS          07/13/73

      PROGRAM MOD
      REAL LIML,LIMU
      INTEGER FS,SHDOW,INDEXT,FIRSTCEL,SUMRY
      DIMENSION SHDOW(16),SUMRY(20),IO(3,10),LIML(4),LIMU(4)
      DATA(IO=118H  START           END           START I1    END     I1     STAR
     *T I2     END     I2     START I3     END     I3     START I4     END     I4 )
     *,(LIML=70.,40.,15.,1.0),(LIMU=95.,65.,25.,10.)
      COMMON Q(15)
      COMMON DATA(187),IP1(187),ODATA(187),IP2(187),ICHN(187),NW,NC(15),
     *FS,LS,WMTOT(15),AMTOT(15),CWOUT(67),CWIN(67),CWAT(67),CPO(67),
     *CPOW(67),FCDAT(15),PRATE(15),CIN(15),CHI(15),CLO(15),KCB,KT1,KT2,
     *SCV(15,3),ICURST(15),ISP(15)
      COMMON ITEST(5),NWTEST,AMIN,WMIN,
     *NF,QK(15),DELT(15),SLOPE(15),SINTC(15),IOS(6),IORBIT
      DIMENSION STRC(187),TDATA(187),AUX(187),PRESS(187),OSTRC(187),
     *OTDATA(187),OAUX(187),OPRESS(187)
      COMMON/DATA/ IREC,S(11,14,15),NI(15),NV(3,12),NVL(14,2),NVO(3),
     *NT(3,13),
     *NTL(5,2),NA(3,7),NP(3,7),XTR(10,14,2)
      DIMENSION XT(280),NTT(49),SSV(2310),NVV(49)
      EQUIVALENCE (XT,XTR),(NTT,NT),(SSV,S),(NVV,NV)
      EQUIVALENCE (DATA,TIME,TDATA,AUX,PRESS,STRC),(ODATA,OTIME,OTDATA,
     *OAUX,OPRESS,OSTRC)
C
C********** MOD REVISION 5.7 *******************************************
C
C**   THIS BATTERY REDUCTION PROGRAM PROCESSES VARIABLE RECORD LENGTH   *
C**   BCD INSTRUMENTATION TAPES-ALL DATA REFERENCES HAVE BEEN MADE      *
C**   GENERALIZED BY CREATING A DESCRIPTOR ARRAY FROM THE USERSS CHANNEL
C**   ASSIGNMENT CARDS-IT PRODUCES A TAB LISTING BY STRING. A SUMMARY   *
C**   FILE OF ALL ERROR MESSAGES WHICH IS LISTED WHEN ALL DATA IS       *
C**   PROCESSED,AND A BINARY E.U. FORMATTED TAPE WHICH IS INPUT TO A    *
C**** SELECTIVE PLOT PROGRAM-THESE FEATURES HAVE EITHER REPLACED OR     *
C*    MODIFIED THE ORIGINAL CALLDATA PROGRAM                    *********
C
C***     PROGRAMMER          R.QUINN
C***     MACHINE             CDC 3200
C***     OPERATING SYSTEM    MSOS 4.2
C
      NRUN=0
      CALL CARDINPS
      ICARD=0  $        TE=(2./3.) $          TS=1.-TE
    5 DO 10 I=1,2310
   10 SSV(I)=0.
      KR=3
      DO 15 I=1,187
      XT(I)=XT(I+93)=0.
   15 ODATA(I)=0.
      DO 20 I=1,15
      Q(I)=0.
      PRATE(I)=FCDAT(I)=0.
```

APPENDIX Q-13

FINALIZED DATA

REDUCTION/ANALYSIS

PROGRAM (CDC 3200)

```
      CIN(I)=CHI(I)=AMTOT(I)=WMTOT(I)=0.
      CLO(I)=100.
   20 ISP(I)=ICURST(I)=SHDOW(I)=0
C INTIALIZE START OF RUN
      IPP=IOT=IFLAG=ILAST=IFILE=0
      MNUM=1 $        NRUN=NRUN+1 $        IORBIT=IOS(NRUN)-1
   30 IF(ICARD.EQ.0) GO TO 31
C START TO READ RECORDS
      CALL MREAD(IX)
      IF (IX-1) 35,405,410
   31 ICARD=1
C    IX=0 NORMAL RECCRD  IX=1  EOF    IX=2 LAST RECORD
   35 ITEMP=ITIMEMIN(DATA)
      TDIFF=ITEMP-IOT
      IF(TDIFF.LT.0.0) TDIFF=TDIFF+1440.
      IF(IOT.EQ.0.AND.IFLAG.EQ.0) TDIFF=0.
      IOT=ITEMP
      DO 100 J1=1,49
      J=NTT(J1)
      IF(J.EQ.0) GO TO 100
      DATA(J)=DATA(J)*1000.
C     CONVERT DATA FROM VOLTS TO TEMPS
      IF (DATA(J)-1.0570) 50,45,45
   45 TDATA(J)=80.+((DATA(J)-1.0570)/.0229)
      GO TO 95
   50 IF (DATA(J)-0.8320) 60,60,55
   55 TDATA(J)=70.0+((DATA(J)-0.8320)/.0225)
      GO TO 95
   60 IF(DATA(J)-0.6090) 70,70,65
   65 TDATA(J)=60.0+((DATA(J)-0.6090)/.0223)
      GO TO 95
   70 IF (DATA(J)-0.3890) 80,80,75
   75 TDATA(J)=50.0+((DATA(J)-0.3890)/.0220)
      GO TO 95
   80 IF (DATA(J)-0.1710) 90,90,85
   85 TDATA(J)=40.+((DATA(J)-0.1710)/.0218)
      GO TO 95
   90 TDATA(J)=32.+(DATA(J)/.0214)
   95 CONTINUE
  100 CONTINUE
C CALCULATE STRING CURRENT
      DO 105 I1=FS,LS
      I=NI(I1)
  105 STRC(I)=DATA(I)*2000.
      ITT=DATA(2) $        ITI=DATA(1)
      IF (IFLAG.EQ.0) GO TO 115
      IF (ITT.EQ.0) GO TO 110
      CALL ERROR (ITT,ITI,SHDOW)
      GO TO 115
  110 DO 115 I=FS,LS
      IF(SHDOW(I).EQ.10) 111,112
  111 WRITE(6,465) I,ITI,IORBIT
      WRITE(8,466) ICHN(2),IORBIT,I,ITI
C**** SAVE RESTORED TIME MESSAGE ON SUMMARY FILE *****
  112 SHDOW(I)=0
  115 CONTINUE
C CALCULATE POWER IN EACH STRING
      KR=KR+1 $        KCB=MODF(KR,3) $        KT1=MODF(KR-1,3)
      KT2=MODF(KR-2,3)
      DO 125 ISTRI=FS,LS
      PCDAT(ISTRI)=0. $        X=0
      I=NI(ISTRI)
```

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```
****** CHECK STATUS OF STRING CURRENTS
      DO 120 J=1,4
      IF(STRC(I).GE.LIML(J).AND.STRC(I).LE.LIMU(J)) ICURST(ISTRI)=J
  120 CONTINUE
      NCF=FIRSTCEL(ISTRI)
      NCL=NCF+NC(ISTRI)-1
      N=INDEXT(2,ISTRI) $        M=INDEXT(1,ISTRI)
      Q(ISTRI)=Q(ISTRI)+QK(ISTRI)*(TDATA(N)-TDATA(M)-DELT(ISTRI))*TDIFF
C**** ACCUMULATE HEAT IN EACH STRING                    ****
C
      DO 121 K=NCF,NCL
      KV=NVV(K)$          IF(KV.EQ.0) GO TO 121
      X =X+DATA(KV)
      CPOW(K)=DATA(KV)*STRC(I)
      PCDAT(ISTRI)=CPOW(K)+PCDAT(ISTRI)
  121 CONTINUE
      SCV(ISTRI,KCB)=X
  125 CONTINUE
C***** FIND AV,MAX,MIN INLET TEMP FOR ALL STRINGS ****
      IF(IFLAG.EQ.0) GO TO 127
      IPP=IPP+1
      DO 126 I=FS,LS
      K = INDEXT(1,I)
      IF(CLO(I).GT.TDATA(K)) CLO(I)=TDATA(K)
      IF(CHI(I).LT.TDATA(K)) CHI(I)=TDATA(K)
  126 CIN(I)=CIN(I)+TDATA(K)
C CHECK FOR START OF DISCHARGE
      IF (IFLAG.NE.0) GO TO 155
  127 IF( DATA(NF).GT.1) IFLAG=1
      IF (IFLAG.EQ.0) GO TO 270
  135 DO 140 K=FS,LS
      IF(ISP(K).EQ.6) CALL EZSTORE(K,10)
  140 CONTINUE
      DO 145 I=1,67
      IF(NVV(I).EQ.0) GO TO 141
C*******  GET LAST 40 SECONDS OF CHARGE
      CWAT(I)=CWAT(I)+TE*CPO(I)
      CWIN(I)=CWAT(I)-CWOUT(I)
  141 IF(I.GT.LS) GO TO 145
      WWTOT(I)=WWTOT(I)+TE*PRATE(I)
      N=NI(I)
      AMTOT(I)=AMTOT(I)+TE*CSTRC(N)
  145 CONTINUE
      CALL EZSTORE(FS,9)
      IF (IFLAG.EQ.2) GO TO 295
  150 CONTINUE
      CALL EZSTORE(FS,1)
      IORBIT=IORBIT+1
      IFLAG=-1
      GO TO 170
C **** CHECK FOR TRANSITION FROM CHARGE TO DISCHARGE *******
  155 IF(IFLAG.EQ.2.AND.DATA(NF).GT.1) GO TO 135
  170 IF (MNUM-1) 190,175,190
  175 DO 180 J=FS,LS
C****** GET FIRST 20 SECONDS OF DISCHARGE
      WWTOT(J)=PCDAT(J)*TS  $          N=NI(J)
      AMTOT(J)= STRC(N)*TS
C**** RESET HEAT IN EACH STRING AT START OF DISCHARGE **
C
      K=INDEXT(2,J) $        M=INDEXT(1,J)
  180 Q(J)=QK(J)*(TDATA(K)-TDATA(M)-DELT(J))
      ENDFILE 9
```

```
C**** SEPARATE ORBITS ON INTERMEDIATE PLOT TAPE BY FILE MARKS **********
C
      DO 185 I=1,67
  185 CWAT(I)=TS*CPOW(I)
      GO TO 270
C **** CHECK FOR TRANSITION FROM DISCHARGE TO CHARGE *******
  190 IF(ODATA(NF).GT.1.0.AND.DATA(NF).LT.1.0) 191,193
  191 IFLAG=2
      DO 192 I=1,67
C****** GET LAST 40 SECONDS OF DISCHARGE
      CWOUT(I)=CWAT(I)=CWAT(I)+TE*CPO(I)
      CWAT(I)=CWAT(I)+TS*CPOW(I)
      IF(I.GT.LS) GO TO 192
      N=NI(I)
      WMTOT(I)=WMTOT(I)+TE*PRATE(I)
      AMTOT(I)=AMTOT(I)+TE*OSTRC(N)
      CALL EZSTORE(I,2)
C****** GET FIRST 20 SECONDS OF CHARGE
      AMTOT(I)=AMTOT(I)+TS*STRC(N) $       WMTOT(I)=WMTOT(I)+TS*PCDAT(I)
      ISP(I)=3
  192 CONTINUE
      GO TO 270
  193 DO 195 L=FS,LS
      N=NI(L) $        NCF=FIRSTCEL(L) $        NCL=NCF+NC(L)-1
      WMTOT(L)=WMTOT(L)+TDIFF*(.5*(PRATE(L)+PCDAT(L)))
      AMTOT(L)=AMTOT(L)+TDIFF*(.5*(OSTRC(N)+ STRC(N)))
      DO 195 K=NCF,NCL
  195 CWAT (K)=CWAT (K)+TDIFF*(.5*( CPO (K)+ CPOW(K)))
      IF(DATA(72).GT.1.0) GO TO 270
C **** CHECK FOR CURRENT CHANGES DURING CHARGE CYCLE ****
      DO 245 J=FS,LS
      IF(ISP(J).GE.4) GO TO 241
      IF(ICURST(J).EQ.2) 240,245
C**** STORE 50 AMP SWITCH-OVER DATA *****
  240 CALL EZSTORE(J,4) $        ISP(J)=4 $        CALL VSWT(J)
      GO TO 245
  241 IF(ISP(J).GE.5) GO TO 243
      IF(ICURST(J).EQ.3) 242,245
C**** STORE 20 AMP SWITCH-OVER DATA ******
  242 CALL EZSTORE(J,6) $        ISP(J)=5 $        CALL VSWT(J)
      GO TO 245
  243 IF(ISP(J).GE.6.OR.ICURST(J).NE.4) GO TO 245
C**** STORE  5 AMP SWITCH-OVER DATA ******
      CALL EZSTORE(J,8) $        ISP(J)=6 $        CALL VSWT(J)
  245 CONTINUE
  270 DO 275 J=1,NW
  275 ODATA(J)=DATA(J)
      DO 277 J=FS,LS
      NCF=FIRSTCEL(J) $        NCL=NC(J)+NCF-1
      DO 276 I=NCF,NCL
  276 CPO(I)=CPOW(I)
  277 PRATE(J)=PCDAT(J)
C
C***** SAVE VALUES AT TIME T NEEDED AT T+1 ****************************
C
      IF(IFLAG.EQ.0) 279,278
  278 MNUM=MNUM+1
      WRITE(9) ( (Q(I),I=1,15),(DATA(I),I=1,187) ) $        GO TO 30
C**** ONE MINUTE OF DATA TO INT. PLOT TAPE ****************************
C
  279 WRITE(6,510) ( ICHN(I),I,DATA(I),I=1,NW )   $        GO TO 30
  295 DO 390 IJ=FS,LS
```


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```
      WRITE(6,445) ITEST,ICHN(2),IORBIT
      WRITE(6,450) IJ    $        IOK=1
      IF(SHOOW(IJ).EQ.10) WRITE(6,440)
      WRITE(6,455)
      DO 305 IK=1,10
      IF(IK.EQ.3) WRITE(6,460)
      WRITE(6,470) (IO(I,IK),I=1,3),(S(IK,N,IJ),N=1,14)
      J=IJ-12
      IF(J.GT.0.AND.J.LE.2) WRITE(6,471) (XTR(IK,N,J),N=1,14)
      IF(IK.LT.3) GC TO 305
      NL=(IK-1)/2
      IF(S(IK,8,IJ).LT.LIML(NL).OR.S(IK,8,IJ).GT.LIMU(NL)) IOK=0
  305 CONTINUE
      IF(IOK.EQ.0) WRITE(6,525)
      IF(IOK.EQ.0) WRITE(8,526) ICHN(2),IORBIT,IJ
C***** PRINT MESSAGE IF ABNORMAL CHARGE CYCLE
      J1=ITIMEMIN(S(2,4,IJ))-ITIMEMIN(S(1,4,IJ))
      I1=ITIMEMIN(S(10,4,IJ))-ITIMEMIN(S(3,4,IJ))
      IF(J1.NE.35.OR.I1.NE.57) 306,307
  306 WRITE(6,520)
      IF(IJ.EQ.FS) WRITE(8,521) ICHN(2),IORBIT
  307 CONTINUE
C****  CHECK TIMING OF CHARGE CYCLE IF ABNORMAL PRINT ERR MESG.  *******
      AD   =S(11,4,IJ)-S(11,3,IJ) $        WD   =S(11,2,IJ)-S(11,1,IJ)
      APOWER=(AD/S(11,3,IJ))*100. $        WPOWER=(WD/S(11,1,IJ))*100.
      WRITE(6,530) $        WRITE(6,535) S(11,1,IJ),WD,WPOWER
      WRITE(6,540) $        WRITE(6,535) S(11,3,IJ),AD,APOWER
      WRITE(6,530)
      IF(WPOWER.LT.WMIN) WRITE(8,551) ICHN(2),IORBIT,IJ,WPOWER
      IF(APOWER.LT.AMIN) WRITE(8,552) ICHN(2),IORBIT,IJ,APOWER
      NCF=FIRSTCEL(IJ)
      NCL=NCF+NC(IJ)-1
      DO 310 I=NCF,NCL
      IF(NVV(I).EQ.0) GO TO 310
      PER=(CWIN(I)/CWOUT(I))*100.
      CWIN(I)=CWIN(I)/60. $        CWOUT(I)=CWOUT(I)/60.
      WRITE(6,545) I,CWOUT(I),CWIN(I),PER
  310 CONTINUE
      CIN(IJ)=CIN(IJ)/IPP
      WRITE(6,550) CLO(IJ),CHI(IJ),CIN(IJ)
      CLO(IJ)=100. $        CHI(IJ)=0.
C****** RESET LOW AND HIGH INLET TEMP FOR NEXT ORBIT CYCLE  *****
      WRITE(6,555) G(IJ),DELT(IJ)
  390 CONTINUE
      DO 395 I=1,2310
  395 SSV(I)=0.
C***** CURRENT RECORD IS FIRST MINUTE OF DISCHARGE ****
      MNUM=IPP=1
      DO 396 I=1,280
  396 XT(I)=0.
      IF( IFILE.EQ.1 ) 397,398
  397 WRITE(6,480) NRUN $        GO TO 5
  398 IF( ILAST.EQ.1 ) 430,150
C
C***  IF EOF ON INPUT TAPE PRINT CURRENT RESULTS,DOUBLE EOF ON PLOT TAPE
C***  SET IFILE SWITCH ON SO TO END CURRENT RUN AND SET UP FOR NEXT.....
  405 ENDFILE 9 $        ENDFILE 9 $        IFILE=1 $        GO TO 295
  410 WRITE (6,475)
      DO 425 K=FS,LS
      IF (ISP(K)-6) 425,415,425
  415 CALL EZSTORE (FS,9)
      CALL EZSTORE (K,10)
```

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```
      DO 420 I=1,67
      CWIN(I)=CWAT(I)-CWOUT(I)
  420 CONTINUE
  425 CONTINUE
      WRITE(6,435) (WMTOT(J),AMTOT(J),J,J=FS,LS)
      ILAST=1
      GO TO 295
  430 ENDFILE 9
C***  END OF TEST---PRINT SUMRY FILE                                  ***
C
      L=0 $        ENDFILE 8 $        REWIND 8
  431 READ(8,553) SUMRY       $       IF(EOFCKF(8).EQ.1) STOP
      L=L+1 $          L=MODF(L,25) $          IF(L.EQ.1) WRITE(6,554) ITEST
      WRITE(6,553) SUMRY           $          GO TO 431
C
  435 FORMAT (2E20.8,I4)
  440 FORMAT (1H0,120(1H*)/1X,50X,23H ALARM CONDITION EXISTS)
  445 FORMAT(1H1,/////4X,5A4,10H TEST-DATE,I4, 28H STATISTICS FOR ORBIT
     1NUMBER,2X,I10)
  450 FORMAT (1H0,45X,14H STRING NUMBER,I10)
  455 FORMAT (1X,13H DISCHARGE    ,3X,2HC1,4X,2HC2,4X,2HC3,6X,4HTIME,4X,3
     1HCLT,4X,3HTSR,4X,3HSCV,4X,3HAMP,4X,3H A1,4X,5HP1-MV,5X,3H A2,4X,
     25HP2-MV,5X,3H A3,4X,5HP3-MV)
  460 FORMAT (1X,6HCHARGE)
  465 FORMAT (1X,13HSTRING NUMBER,I5,17H  RESTORED TIME= ,I10,7H ORBIT=,
     1I10)
  466 FORMAT(1H0,I3,I6,I7,13H RESTORED AT ,I7,43(1H ))
  470 FORMAT(1X,3A4,3(1X,F6.3),1X,F8.0,4(1X,F6.3),3(F7.4,F10.5))
  471 FORMAT(13X,3F7.3,2X,6F7.3,2(F10.3,F7.3),F7.3)
  475 FORMAT (1H1,30X,25H LAST RECORD ENCOUNTERED )
  480 FORMAT (1X,19H END OF RUN NUMBER ,I5)
  510 FORMAT(1X,5(2I4,F15.5))
  520 FORMAT(1H0,1X,10(1H*),37H WARNING CHARGE CYCLE TIMING ABNORMAL,1X,
     *10(1H*))
  521 FORMAT(1H0,I3,I6,32H-*****-     CYCLE TIMING ABNORMAL,38(1H ))
  525 FORMAT(1X,/,1X,10(1H*),29HWARNING CHARGE CYCLE ABNORMAL,10(1H*),/)
  526 FORMAT(1H0,I3,I6,I7,22H CHARGE CYCLE ABNORMAL,41(1H ))
  530 FORMAT(17H0 WATT-HOURS OUT ,10X,15H WATT-HOURS IN,10X,15H PERCENT
     *RETURN)
  535 FORMAT(1X,3(F14.2,9X))
  540 FORMAT(17H0 AMP-HOURS OUT  ,10X,15H AMP-HOURS IN ,10X,15H PERCENT
     *RETURN)
  545 FORMAT(1X,I3,3(F11.2,12X))
  550 FORMAT(1H0,/,10X,50H THERMAL INFORMATION - INLET TEMPERATURE IN DE
     *G F ,/,1H0,10X,5H LOW ,10X,6H HIGH ,10X,5H AVER,/,3(9X,F6.3))
  551 FORMAT(1H0,I3,I6,I7,25H PERCENT WATT RETURN LOW=,F6.1,12(1H ))
  552 FORMAT(1H0,I3,I6,I7,25H PERCENT AMP  RETURN LOW=,F6.1,12(1H ))
  553 FORMAT(20A4)
  554 FORMAT(1H1////15X,32HSUMMARY OF ERROR CONDITIONS FOR ,5A4,/, 18H0
     *DAY ORBIT STRING)
  555 FORMAT(26H0  TOTAL HEAT IN WATT-HRS=,F7.2,20H AMBIENT CORRECTION=,
     *F8.4,10H DEGREES F)
      END
```

PROGRAM VARIABLES

01051	R	AD	00732	I	ILAST	00736	I	IX	01027	I	M	00546	I	SHDOW
01055	R	APOWER	00612	I	IO	00747	I	J	00734	I	MNUM	00566	I	SUMRY
00713	I	I	01040	I	IOK	00745	I	J1	01026	I	N	00741	R	TDIFF
01010	I	I1	00730	I	IOT	01030	I	K	01024	I	NCF	00705	R	TE
00700	I	ICARD	00727	I	IPP	00720	I	KR	01025	I	NCL	00707	R	TS
00733	I	IFILE	01020	I	ISTRI	01031	I	KV	01047	I	NL	01053	R	WD

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00731 I	IFLAG	00740 I	ITEMP	01034 I	L	00676 I	NRUN	01057 R	WPOWER
01037 I	IJ	01014 I	ITI	00650 R	LIML	01061 R	PER	01021 R	X
01041 I	IK	01013 I	ITT	00660 R	LIMU				

COMMON VARIABLES

04476 R	AMIN	02611 R	CWOUT	04451 I	ISP	01117 R	OAUX	04503 R	QK
02553 R	AMTOT	00036 R	DATA	04470 I	ITEST	01117 R	ODATA	04300 R	SCV
00036 R	AUX	04541 R	DELT	04275 I	KCB	01117 R	OPRESS	04635 R	SINTC
04201 R	CHI	02513 I	FS	04276 I	KT1	01117 R	OSTRC	04577 R	SLOPE
04143 R	CIN	02200 I	ICHN	04277 I	KT2	01117 R	OTDATA	00036 R	STRC
04237 R	CLO	04432 I	ICURST	02514 I	LS	01117 R	OTIME	00036 R	TDATA
03433 R	CPO	04701 I	IORBIT	02474 I	NC	04047 R	PCDAT	00036 R	TIME
03641 R	CPO*	04673 I	IOS	04502 I	NF	04105 R	PRATE	04500 R	WMIN
03225 R	CWAT	00624 I	IP1	02473 I	NW	00036 R	PRESS	02515 R	WMTOT
03017 R	CWIN	01705 I	IP2	04475 I	NWTEST	00000 R	Q		

DATA VARIABLES

00000 I	IREC	11245 I	NP	11137 I	NTT	11134 I	NVO	00001 R	SSV
11220 I	NA	11137 I	NT	11034 I	NV	11034 I	NVV	11272 R	XT
11015 I	NI	11206 I	NTL	11100 I	NVL	00001 R	S	11272 R	XTR

STATEMENT NUMBERS

5 01361	95 01671	155 02460	276 03131	415 04145	480 00220
10 01363	100 01672	170 02473	277 03143	420 04163	510 00230
15 01405	105 01707	175 02500	278 03161	425 04173	520 00235
20 01436	110 01751	180 02531	279 03220	430 04233	521 00256
30 01471	111 01760	185 02554	295 03246	431 04244	525 00274
31 01507	112 02006	190 02570	305 03445	435 00000	526 00313
35 01511	115 02011	191 02600	306 03550	440 00003	530 00327
45 01571	120 02102	192 02663	307 03571	445 00017	535 00350
50 01600	121 02177	193 02674	310 03767	450 00042	540 00354
55 01606	125 02212	195 02732	390 04040	455 00052	545 00375
60 01615	126 02270	240 03003	395 04052	460 00120	550 00402
65 01623	127 02312	241 03016	396 04071	465 00124	551 00441
70 01632	135 02331	242 03032	397 04107	466 00144	552 00457
75 01640	140 02345	243 03045	398 04116	470 00157	553 00475
80 01647	141 02376	245 03071	405 04122	471 00174	554 00477
85 01655	145 02423	270 03101	410 04131	475 00206	555 00522
90 01664	150 02445	275 03103			

EXTERNAL REFERENCES

CARDINPS	ERRCR	FIRSTCEL	ITIMEMIN	MREAD
EOFCKF	EZSTORE	INDEXT	MODF	VSWT

FORTRAN DIAGNOSTIC RESULTS FOR MOD

COMPILED LENGTHS OF MOD = P 04344 C 04702 D 12352

NO ERRORS

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```
      SUBROUTINE EZSTORE(NS,IA)
      INTEGER FS,INDEXT
      DIMENSION JA(14),JP(14),INDEX(14),JV(3),LX(14)
      EQUIVALENCE (JA,JP,INDEX,JV),(N,INDEX(8)),(NT1,INDEX(5)),(NT2,INDE
     *X(6))
      COMMON Q(15)
      COMMON D(187),IP1(187),OD(187),IP2(390),FS,LS,W(15),A(15),M(820),
     *KCB,KT1,KT2,SCV(15,3)
      COMMON/DATA/ IR,S(11,14,15),NI(15),NV(3,12),NVL(14,2),NVO(3),
     *NT(3,13),
     *NTL(5,2),NA(3,7),NP(3,7),XTR(10,14,2)
      DATA (INDEX(4)=1),(LX(3)=0)
C
C****  EZSTORE STORES ORBIT STATISTICS AT TIMES DETERMINED
C****  BY THE MAIN PROGRAM  IT REPLACES TERFIL,VOLFIL,SETIM,OLFIVE,
C****  WATFIL,EIGHTY,FIFTY,TWEN,FIVE
C
      IB=IA
      INEW=IOLD=1 $        K1F=K2F=NS
      IF(IA.EQ.1.OR.IA.EQ.9) 1,2
C
C**** IF IA=1 MAIN PROGRAM WANTS TO STORE ONLY CURRENT VALUES ****
C****  BUT FOR ALL ACTIVE STRINGS                              ****
C
 1    K1F=FS $        K2F=LS $        IOLD=0
      IF(IA.EQ.1) IB=0
 2    IF(IA.EQ.10) INEW=0
C
C**** IF IA=10 MAIN PROGRAM WANTS TO STORE ONLY OLD VALUES    ****
C****   FOR STRING NO. NS  THIS ACCOMPLISHES OLFIVE            ****
C
      DO 17 J=K1F,K2F
      IF(IA.EQ.2) 3,4
 3    S(11,1,J)=W(J)/60. $        S(11,3,J)=A(J)/60.
 4    IF(IA.EQ.9) 5,6
 5    S(11,2,J)=W(J)/60. $        S(11,4,J)=A(J)/60. $        GO TO 17
C**** DO WHAT WATFIL USED TO DO ***
C
 6    N=NI(J) $        NT1=INDEXT(2,J) $        NT2=INDEXT(3,J)
      NS14=0  $        I=J-12
      IF(I.GT.0.AND.I.LE.2) 7,10
 7    NS14=1 $        LX(1)=INDEXT(4,J) $        LX(2)=INDEXT(5,J)
      DO 8 K=4,14
 8    LX(K)=NVL(K,I)
      DO 9 K=1,14
      L=LX(K) $        IF(L.EQ.0) GO TO 9
      IF(IOLD.EQ.1) XTR (IB,K,I)=OD(L)
      IF(INEW.EQ.1) XTR (IB+1,K,I)=D(L)
 9    CONTINUE
C
CC****FOR STRINGS 13 AND 14 STORE VALUES OF 2XTR TEMPS AND 11XTR CELVS**
CC
 10   DO 14 J3=1,3
      IF(J.LT.3.OR.J.GT.9) 11,12
 11   JA(2*J3+7)=0 $        JP(2*J3+8)=0 $        GO TO 13
 12   JA(2*J3+7)=NA(J3,J-2) $        JP(2*J3+8)=NP(J3,J-2)
 13   JV(J3)=NV(J3,J)
      IF(J.EQ.15) JV(J3)=NVO(J3)
      IF(NS14.EQ.1) JV(J3)=NVL(J3,J-12)
 14   CONTINUE
```

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```
      DC 16 K=1,14
      IF(K.EQ.7) GO TO 15
      L=INDEX(K)
      IF(L.EQ.0) GO TO 16
      X=1.
      IF(K.EQ.10.OR.K.EQ.12.OR.K.EQ.14) X=1000.
C
C***** SCALE PRESSURE READINGS TO MILLIVOLTS FOR DISPLAY ONLY ****
C
      IF(IOLD.EG.1) S(IB,K,J)=OD(L)*X
      IF(INEW.EG.1) S(IB+1,K,J)=D(L)*X
      GO TO 16
   15 IF(IOLD.EG.1) S(IB,7,J)=SCV(J,KT1)
      IF(INEW.EC.1) S(IB+1,7,J)=SCV(J,KCB)
   16 CONTINUE
   17 CONTINUE
      RETURN
      END
```

PROGRAM VARIABLES

00056	I	I	00036	I	IOLD	00000	I	JP	00041	I	K2F	00055	I	NS14
00034	I	IB	00046	I	J	00000	I	JV	00063	I	L	00004	I	NT1
00000	I	INDEX	00066	I	J3	00061	I	K	00016	I	LX	00005	I	NT2
00035	I	INEW	00000	I	JA	00040	I	K1F	00007	I	N	00072	R	X

COMMON VARIABLES

02553	R	A	00624	I	IP1	04276	I	KT1	02611	I	M	04300	R	SCV
00036	R	D	01705	I	IP2	04277	I	KT2	01117	R	OD	02515	R	W
02513	I	FS	04275	I	KCB	02514	I	LS	00000	R	Q			

DATA VARIABLES

00000	I	IR	11245	I	NP	11206	I	NTL	11100	I	NVL	00001	R	S
11220	I	NA	11137	I	NT	11034	I	NV	11134	I	NVO	11272	R	XTR
11015	I	NI												

STATEMENT NUMBERS

1	00323	4	00366	7	00433	10	00530	13	00555	16	00722
2	00341	5	00372	8	00447	11	00541	14	00602	17	00732
3	00356	6	00403	9	00520	12	00547	15	00700		

EXTERNAL REFERENCES

INDEXT

FORTRAN DIAGNOSTIC RESULTS FOR EZSTORE

COMPILED LENGTHS OF EZSTORE - P 01002 C 04432 D 12352

NO ERRORS

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```
      SUBROUTINE CARDINPS
      INTEGER CARD
      INTEGER RUNFLG,FS
      INTEGER R,CHN,STRN
      CHARACTER MT,MTT,MTA,CHDEFLG
      COMMON Q(15)
      COMMON IDUMMY(1122),ICHN(187),NW,NC(15),FS,LS
      COMMON IQ(1003),ITEST(5),NWT,AM,WM,
     *NF,QK(15),DELT(15),SL(15),SI(15),IOS(6),IORBIT
      COMMON/DATA/ R,CHN(10),MT(187),MN(187),MTA(8),NEC(173),MTT(173),
     *MCT(173),MST(173),CHDEFLG(187),MS(187),MC(187),IP(3390),NEW(173)
      DIMENSION MTTW(44),MTAT(2),MTW(47),MCHD(47)
      EQUIVALENCE (MTTW,MTT),(MTAT,MTA),(MCHD,CHDEFLG),(MTW,MT)
      DATA (MTTW=3(4HIIII),4HIIIV,16(4HVVVV),4HVVTT,11(4HTTTT),
     *4HTTTA,5(4HAAAA),5(4HPPPP),1HP),
     *      (MST =1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,3(1),3(2),3(3),3(4)
     *,3(5),3(6),3(7),3(8),3(9),3(10),3(11),3(12),14(13),14(14),3(15),
     *3(1),3(2),3(3),3(4),3(5),3(6),3(7),3(8),3(9),3(10),3(11),3(12),
     *3(15),
     *5(13),5(14),3(3),3(4),3(5),3(6),3(7),3(8),3(9),3(3),3(4),3(5),3(6)
     *,3(7),3(8),3(9)),
     *      (MCT=15(1),12(1,2,3),2(1,2,3,4,5,6,7,8,9,10,11,12,13,14),
     *1,2,3,
     *13(1,2,3),2(1,2,3,4,5),7(1,2,3),7(1,2,3)),
     *      (MTAT=8HIVTAPC* )
      DATA (NEC=173(0)),(MS=187(0)),(NEW=173(0)),(MN=187(0)),
     *                        (MCHD=47(66666666B))
      DO 98 I=1,15
   98 QK(I)=DELT(I)=0.
      READ(5, 24) ITEST,NWT,AM,WM,NF,IOS
   99 READ(5, 25) J,V1,T1,V2,T2,W,FT
      IF(J.LE.0.OR.J.GT.15) GO TO 100
      SL(J)=(V1-V2)/(T1-T2) $        SI(J)=V1-SL(J)*T1
      QK(J)= W*.0048804      $       DELT(J)=FT $         GO TO 99
C***
C*** READ V VS T TWO-POINT CALIB,FLOW-RATE,AND AMBIENT T FOR STRING J
C*** CONTINUE TO CHANNEL ASSIGNMENTS WHEN J=0
  100 ISTAR= 9999 $          FS=LS=RUNFLG=0
      FS=LS=RUNFLG=0
    1 READ(5,17) STRN,NC(STRN),(CHN(I),MT(I),MN(I),I=1,10),CARD
      WRITE(6,18)STRN,NC(STRN),(CHN(I),MT(I),MN(I),I=1,10),CARD
      IF(FS.EQ.0) FS=STRN
C........ STRING NO. ON FIRST ASSGMT CARD IS FIRST ACTIVE STRING FS ....
      DO 7 I=1,10
      KT=8
      DO 2 K=1,7
      IF(MT(I).EQ.MTA(K)) KT=K
    2 CONTINUE
      GO TO(3,1,8,6),KT-4
C** TYPE FIELD IS  LEGAL THEN CONTINUE VERIFICATION
C                     =C   USER WANTS TO GO TO NEXT CARD
C                     =*   USER FLAGS THIS IS LAST CARD-STRN=LAST ACT.STRN
C                     ILLEGAL THEN SET RUNFLG,WRITE ERR.MSG AND CONTINUE
    3 DO 5 J=1,173
      IF(NEC(J).NE.0) GO TO 5
      IF(MT(I).EQ.MTT(J).AND.MN(I).EQ.MCT(J).AND.MST(J).EQ.STRN) 4,5
    4 NEC(J) = CHN(I) $        GO TO 7
C
C** SEARCH ORDERED TABLE FOR A MATCH-WHEN FOUND SAVE USER CHAN IN
C** CORRESPONDING ENTRY IN-NEC ARRAY-NOTE-PREVIOUSLY REQUESTED ENTRIES
```

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```
C** ARE SKIPPED OVER
    5   CONTINUE
    6   RUNFLG=1 $        WRITE(6,19) I,CARD
    7   CONTINUE
        GO TO 1
    8   LS=STRN
        CALL MREAD(IX)
C
C** READ FIRST REC ON DATA TAPE-AND SEARCH NEC  FOR ALL NON-ZERO ENTRIES
C FOR ALL I  WHEN MATCH IS FOUND WORD INDEX-I- IS STORED IN DESCRIPTOR
C ARRAY-NEW- AND SET FLAG FOR WORD-I-TO ASSIGNED- J IS THE RELATIVE
C WORD INDEX IN THE REQUESTED CHAN ARRAY-NEC.
C
        DO 11 J=1,173
        DO 10 I=3,NW
        IF(NEC(J).EQ.0) GO TO 11
        IF(NEC(J).EQ.ICHN(I).AND.CHDEFLG(I).NE.0) 9,10
    9   NEW(J) = I $          CHDEFLG(I)=0 $          GO TO 11
   10   CONTINUE
        WRITE(6,23) NEC(J) $        RUNFLG=1
   11   CONTINUE
        DO 14 I=1,NW
        MT(I)=MTA(7) $          MC(I)=MS(I)=ISTAR
        DO 13 J=1,173
        IF(NEW(J).EQ.I) 12,13
   12   MT(I)=MTT(J) $          MS(I)=MST(J) $        MC(I)=MCT(J)
        GO TO 14
   13   CONTINUE
   14   CONTINUE
        WRITE(6,22)
        DO 15 N=1,50
        WRITE(6,20) (ICHN(I),I,MT(I),MC(I),MS(I),I=N,NW,50)
C......... LIST DESCRIPTOR FOR USER REFERENCE  .......................
   15   CONTINUE
        IF(RUNFLG.EQ.0) GO TO 16
        WRITE(6,21)              $         STOP
   16   WRITE(6,26)
        WRITE(9) (NEW(I),I=1,173)
C......... PASS CONSTRUCTED DESCRIPTOR ONTO PLOT TAPE ................
        RETURN
   17   FORMAT(2I2,1X,10(I3,A1,I2,1X),3X,I2)
   18   FORMAT(1X,2I3,1X,10(I4,1X,A1,I3,1X),3X,I2)
   19   FORMAT(16H ERROR IN FIELD ,I2,10H CARD NO. ,I2)
   20   FORMAT(4(1X,I4,I5,2X,A1,I6,I5))
   21   FORMAT(26H CHANNEL ASSIGNMENT ERRORS)
   22   FORMAT(1H1,4(24HCHAN**WD.*TYP*CELL*STR* ))
   23   FORMAT(12H CHANNEL NO.,I4,12H NOT ON TAPE)
   24   FORMAT(5A4,I4,2F6.1,I4,6I5)
   25   FORMAT(I5,6F10.5)
   26   FORMAT(1H1)
        END
```

PROGRAM VARIABLES

00110	I	CARD	00155	I	IX	00146	I	KT	00112	I	STRN	00122	R	V1
00134	R	FT	00121	I	J	00157	I	N	00124	R	T1	00126	R	V2
00113	I	I	00150	I	K	00111	I	RUNFLG	00130	R	T2	00132	R	W
00141	I	ISTAR												

COMMON VARIABLES

04476	R	AM	00036	I	IDUMMY	04470	I	ITEST	02473	I	NW	04635	R	SI

```
 04541 R    DELT        04701 I    IORBIT      02514 I    LS          04475 I    NWT         04577 R    SL
 02512 I    FS          04673 I    IOS         02474 I    NC          00000 R    Q           04500 R    WM
 02200 I    ICHN        02515 I    IQ          04502 I    NF          04503 R    QK

     DATA VARIABLES

 01452 C    CHDEFLG     01452 I    MCHC        01175 I    MST         00644 C    MTT         00367 I    NEC
 00001 I    CHN         00720 I    MCT         00013 C    MT          00644 I    MTTW        11015 I    NEW
 02317 I    IP          00072 I    MN          00365 C    MTA         00013 I    MTW         00000 I    R
 02024 I    MC          01531 I    MS          00365 I    MTAT

     STATEMENT NUMBERS

      1 00346          6 00555         11 00662         16 01026         21 00043         26 00106
      2 00470          7 00567         12 00711         17 00000         22 00053         98 00215
      3 00511          8 00600         13 00722         18 00010         23 00064         99 00254
      4 00540          9 00632         14 00732         19 00021         24 00075        100 00334
      5 00545         10 00641         15 01003         20 00034         25 00103

     EXTERNAL REFERENCES

          MREAD

              FORTRAN DIAGNOSTIC RESULTS  FOR    CARDINPS

   COMPILED LENGTHS OF CARDINPS - P   01074    C   04702    D   11272
 NO ERRORS
```

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```
      SUBROUTINE MREAD(IF)                                              A00545
      CHARACTER XP                                                      A00546
      INTEGER R                                                         A00547
      DIMENSION ID(561),LFM(3),XP(4)                                    A00548
      COMMON Q(15)                                                      A00549
      COMMON DATA(187),IOD(748),ICHN(187),N                             A00550
      COMMON IQ(1025),NWT                                               A00551
      DATA (LFM=12H( I4,  F7.0))                                        A00552
      EQUIVALENCE (XP,LFM(3)),(ID,DATA)                                 A00553
      COMMON/DATA/ R                                                    A00554
      DATA (R=0)                                                        A00555
    5 IF=IPAR=0                                                         A00556
    6 BUFFER IN (1,0) (ID(1),ID(561))                                   A00557
   10 GO TO(10,25,15,20),UNITSTF(1)                                     A00558
   15 IF=1$RETURN                                                       A00559
   20 IPAR=IPAR+1                                                       A00560
      IF(IPAR.GT.5) GO TO 46                                            A00561
      BACKSPACE 1                                                       A00562
      GO TO 6                                                           A00563
   25 N2=LENGTHF(1) $          N=N2/3                                   A00564
      R=R+1                                                             A00565
      IF(N2.EQ.3*NWT) 30,26                                             A00566
   26 WRITE(6,60) R $         GO TO 5                                   A00567
   30 DECODE(12,50,ID(2)) DATA(1),ICHX                                  A00568
      IF (ICHX.GE.400) 35,40                                            A00569
   35 IF=2$RETURN                                                       A00570
   40 I=1                                                               A00571
      DO 45 KW=4,N2,3                                                   A00572
      KC=KW+2          $          I=I+1                                 A00573
      XP(3) = ID(KC)                                                    A00574
      IF(XP(3).GE.8)XP(3)=0                                             A00575
   45 DECODE(11,LFM,ID(KW))ICHN(I),DATA(I)                              A00576
      ICHN(1)=R                                                         A00577
      RETURN                                                            A00578
   46 R=R+1                                                             A00579
      WRITE(6,55)R                                                      A00580
      GO TO 5                                                           A00581
   55 FORMAT(1H ,35(1H*), 9H WARNING , 35(1H*)/1H ,28(1H*),23H PARITY ER A00582
     *ROR ON RECORD,I5,1X,27(1H*))                                      A00583
   50 FORMAT(1X,F6.0,1X,I4)                                             A00584
   60 FORMAT(1H0, 7H RECORD,I5,21H SKIPPED-LENGTH ERROR)                A00585
      END                                                               A00586
```

PROGRAM VARIABLES

00064 I	I	00051 I	IPAR	00065 I	KW	00056 I	N2	00047 C	XP
00061 I	ICHX	00067 I	KC	00045 I	LFM				

COMMON VARIABLES

00036 R	DATA	00036 I	ID	02474 I	IQ	04475 I	NWT	00000 R	Q
02200 I	ICHN	00624 I	IOD	02473 I	N				

DATA VARIABLES

00000 I	R

STATEMENT NUMBERS

5 00110	15 00132	26 00171	40 00221	46 00277	55 00000

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```
      6 00113            20 00135          30 00200          45 00247          50 00026          60 00032
     10 00120            25 00151          35 00216

     EXTERNAL REFERENCES

          LENGTHF                 UNITSTF

               FORTRAN DIAGNOSTIC RESULTS  FOR    MREAD

  COMPILED LENGTHS OF MREAD    - P   00335   C   04476   D   00001
NO ERRORS
```

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```
      FUNCTION ITIMEMIN(X)                                          A00587
      IHR= X/10000.                                                 A00588
      IMIN=(X-10000*IHR)/100                                        A00589
      ITIMEMIN= 60*IHR+IMIN                                         A00590
C THIS FUNCTION ISOLATES THE HOURS AND MINUTES STORED IN X AND RETURNS A00591
C  THE EQUIVALENT NUMBER OF MINUTES                                  A00592
      RETURN                                                        A00593
      END                                                           A00594
```

PROGRAM VARIABLES

00003 I   IHR   00004 I   IMIN

EXTERNAL REFERENCES

SYSTEM EXTERNALS ONLY

FORTRAN DIAGNOSTIC RESULTS FOR ITIMEMIN

COMPILED LENGTHS OF ITIMEMIN - P 00057 C 00000 D 00000
NO ERRORS

```
      FUNCTION MODF(M,N)                                      A00595
      MODF=M-((M-1)/N)*N                                      A00596
      RETURN                                                  A00597
      END                                                     A00598

            FORTRAN DIAGNOSTIC RESULTS  FOR    MODF

   COMPILED LENGTHS OF MODF     = P   00044   C   00000   D   00000
 NO ERRORS
```

```
      SUBROUTINE ERROR (ID,ID1,S)                                       A00600
      INTEGER S                                                         A00601
      DIMENSION S(16)                                                   A00602
      DIMENSION IPLAC(6)                                                A00603
      DO 5 I=1,6                                                        A00604
      IPLAC(I)=ID/10**(6-I)                                             A00605
      ID=ID-IPLAC(I)*10**(6-I)                                          A00606
5     CONTINUE                                                          A00607
      CALL CON (IPLAC,ID1,S)                                            A00608
      RETURN                                                            A00609
      END                                                               A00610
```

PROGRAM VARIABLES

```
00006 I    I              00000 I    IPLAC
```

STATEMENT NUMBERS

```
5 00044
```

EXTERNAL REFERENCES

```
CON
```

FORTRAN DIAGNOSTIC RESULTS FOR ERROR

```
COMPILED LENGTHS OF ERROR   - P  00113  C  00000  D  00000
NO ERRORS
```

```
      SUBROUTINE CON (III,ID,SS)                                        A00612
      INTEGER SS                                                        A00613
      DIMENSION SS(16)                                                  A00614
      DIMENSION III(6)                                                  A00615
      COMMON IP(1153),IDAY,IQ(1343),IORBIT                              A00616
      DO 10 J=1,6                                                       A00617
      IF (J.EQ.6) IST=0                                                 A00618
      IF (J.EQ.5) IST=3                                                 A00619
      IF (J.EQ.4) IST=6                                                 A00620
      IF (J.EQ.3) IST=9                                                 A00621
      IF (J.EQ.2) IST=12                                                A00622
      IF (J.EQ.1) IST=15                                                A00623
      IDAT=III(J)                                                       A00624
      DO 10 I=1,3                                                       A00625
      MASK=2**(I-1)                                                     A00626
      INT=AND(MASK,IDAT)                                                A00627
      IST=IST+1                                                         A00628
      IF (SS(IST).EQ.10) GO TO 10                                       A00629
      IF (INT.NE.0) 5,10                                                A00630
    5 WRITE(6,15) IST,ID $ SS(IST)=10                                   A00631
      WRITE(8,20) IDAY,IORBIT,IST,ID                                    A00632
   10 CONTINUE                                                          A00633
      RETURN                                                            A00634
C                                                                       A00635
   15 FORMAT(1X,25(1H*),5HALARM,1X,25(1H*),///7H STRING,I5,16H SHUTDOWN A00636
     1 TIME= ,I10)                                                      A00637
   20 FORMAT(1H0,I3,I6,I7,13H SHUTDOWN AT ,I7,43(1H ))                  A00638
      END                                                               A00639
```

PROGRAM VARIABLES

00053	I	I	00055	I	INT	00041	I	IST	00036	I	J	00054	I	MASK
00052	I	IDAT												

COMMON VARIABLES

02201	I	IDAY	04701	I	IORBIT	00000	I	IP	02202	I	IQ

STATEMENT NUMBERS

5 00173	10 00222	15 00000	20 00022

EXTERNAL REFERENCES

AND

FORTRAN DIAGNOSTIC RESULTS FOR CON

COMPILED LENGTHS OF CON - P 00275 C 04702 D 00000

NO ERRORS

```
      FUNCTION FIRSTCEL(J)                                   A00640
      INTEGER FIRSTCEL                                       A00641
      IF(J.LE.12)       1,2                                  A00642
    1 FIRSTCEL=3*(J-1)+1     $        RETURN                 A00643
    2 IF((J-1)/2.EQ.6) 3,4                                   A00644
    3 FIRSTCEL=14*(J-13)+37 $         RETURN                 A00645
    4 FIRSTCEL=65                                            A00646
      RETURN                                                 A00647
      END                                                    A00648
```

STATEMENT NUMBERS

1 00020	2 00026	3 00035	4 00043

FORTRAN DIAGNOSTIC RESULTS FOR FIRSTCEL

COMPILED LENGTHS OF FIRSTCEL - P 00074 C 00000 D 00000
NO ERRORS

```
      FUNCTION INDEXT(I,J)                                              A00649
      COMMON/DATA/ K(4703),NT(3,13),NTL(5,2)                            A00650
C                                                                       A00651
      IF(J.LE.12) 1,2                                                   A00652
    1 INDEXT=NT(I,J) $        RETURN                                    A00653
    2 IF(J.EQ.15) 3,4                                                   A00654
    3 INDEXT=NT(I,13) $        RETURN                                   A00655
    4 INDEXT=NTL(I,J-12)                                                A00656
      RETURN                                                            A00657
      END                                                               A00658

      DATA VARIABLES

  00000 I    K              11137 I    NT              11206 I    NTL

      STATEMENT NUMBERS

        1 00050              2 00054              3 00060              4 00064

                FORTRAN DIAGNOSTIC RESULTS  FOR    INDEXT

    COMPILED LENGTHS OF INDEXT   - P   00123   C   00000   D   11220
  NO ERRORS
```

```
      SUBROUTINE VSWT(J)
      INTEGER INDEXT,FIRSTCEL,K,Y,S
      COMMON/DATA/ M(4621),NI(15),NVV(67)
      COMMON Q(15)
      COMMON TDATA(187),X(187),OSTRC(187),Y(375),NC(15),Z,WM(15),AM(15),
     *C(134),CWAT(67),CPO(67),CPOW(67),PCDAT(15),PRATE(15),S(91),KT1,KT2
     *,VST(15,3),IK(30)
      COMMON IP(71),SLOPE(15),SINTC(15)
      DIMENSION STRC(187)
      EQUIVALENCE (STRC,TDATA)
      K=INDEXT(3,J) $       NCF=FIRSTCEL(J) $       NCL=NCF+NC(J)-1
      TEMP=TDATA(K) $       N=1
      IF( (J-1)/2.EQ.6 ) 100,101
  100 DO 101 L=4,5
      K= INDEXT(L,J) $       IF(K.EQ.0) GO TO 101
      N= N+1        $       TEMP=TEMP+TDATA(K)
  101 CONTINUE
C***** MAKE SURE ALL CELLS ARE ASSIGNED NCC=TOTAL NO. OF CELLS FOR STR J
      NCC=0
      DO 1 I=NCF,NCL
      IF(NVV(I).NE.0) NCC=NCC+1
    1 CONTINUE
      VLIM= NCC*( SLOPE(J)*(TEMP/N)+SINTC(J) )
C
C... COMPUTE THE PREDICTED SWITCHOVER STRING VOLTAGE USING THE ACTUAL NO
C...  OF CELLS AND THE AVERAGE STACK TEMPERATURE--NOTE-- STRINGS 13 AND
C...  14 HAVE THREE STACK READINGS
C... NOW USING STRING VOLTAGES AT T-1 AND T-2 COMPUTE THE PREDICTED
C...  SWITCHOVER TIME INCREMENT AT TIME T
C
      DELV=VST(J,KT1)-VST(J,KT2)
      IF(DELV.LE.0) RETURN
      DT=(VLIM-VST(J,KT1))/DELV
      IF(DT .LE. 0) RETURN
      IF(DT .GT.1.) DT=1.
      IN=1 $       K=NI(J) $       TCORR=AM(J)
      DK1=OSTRC(K) $       DK2=STRC(K) $       GO TO 200
C**** USE CORRECTION FORMULA AT 200 FOR AMP.MEN AND WATT MIN
    2 AM(J)=TCORR  $       DK1=PRATE(J) $       DK2=PCDAT(J)
      IN=2 $       TCORR=WM(J)
  200 DCORR=(DK1-DK2)*(DT-.5)
      IF(SSWTCHF(1).EQ.1) WRITE(6,5) J,DCORR,VLIM,DT,TDATA(1)
    5 FORMAT(8H0STRING=,I2, 7H DCORR=,F10.6, 6H VLIM=,F10.6, 4H DT=,F10.
     *6,6H TIME=,F6)
C.... FOR DEBUG PRINT VLIM PARAMETERS IF SJ1 ON ....................
C
      TCORR=TCORR + DCORR
      GO TO(2,3) IN
    3 WM(J)=TCORR
      DO 4 I=NCF,NCL
      DCORR=(CPO(I)-CPOW(I))*(DT-.5)
    4 CWAT(I)=CWAT(I)+DCORR
      RETURN
      END
```

PROGRAM VARIABLES

00064	R	DCORR	00047	R	DT	00022	I	K	00040	I	NCC	00054	R	TCORR
00044	R	DELV	00041	I	I	00034	I	L	00024	I	NCF	00027	R	TEMP
00056	R	DK1	00053	I	IN	00031	I	N	00025	I	NCL	00042	R	VLIM

```
0006  R     DK2

     COMMON VARIABLES

02553 R   AM        04432 I   IK        01117 R   OSTRC     04635 R   SINTC     02515 R   WM
02611 R   C         04470 I   IP        04047 R   PCDAT     04577 R   SLOPE     00624 I   X
03433 R   CPO       04276 I   KT1       04105 R   PRATE     00036 R   STRC      01705 I   Y
03641 R   CROW      04277 I   KT2       00000 R   Q         00036 R   TDATA     02513 R   Z
03225 R   CWAT      02474 I   NC        04143 I   S         04300 R   VST

     DATA VARIABLES

00000 I   M         11015 I   NI        11034 I   NVV

     STATEMENT NUMBERS

   1 00264         3 00442         5 00000       100 00214       101 00240       200 00376
   2 00363         4 00457

     EXTERNAL REFERENCES

          FIRSTCEL            INDEXT             SSWTCHF

               FORTRAN DIAGNOSTIC RESULTS  FOR    VSWT

  COMPILED LENGTHS OF VSWT     - P   00533   C   04673   D   11137
NO ERRORS
FORTRAN*I=2*L*M

                    MS FORTRAN (4.2)/MSOS             07/13/73

      PROGRAM OBRPLOT
      CHARACTER STRING,IX,IY
      INTEGER DESC
      COMMON   DATA(202),AMAXMIN(4),PMAX(4),PMIN(4),IT(4),
     1   IQ(94,10),IAMP(94,10),IVOLTA(94,10,3),ITEMPA(94,10),
     2   IVOLTB(94,2,14),ITEMPB(94,2,3),IAUX(94,7,3),IPRESS(94,6),
     3   IXRAY(94),IYRAY(94),ICON(6),LABELS(47),DESC(173),STRING(16),
     4   IX(16,3),IY(16,3),IQL(15)
      REAL ICON
      DIMENSION IDENT(5),IBDX(10),IBDY(10),ITITLE(10),INFOX(12)
      EQUIVALENCE(LABELS(1),IDENT),(LABELS(6),IBDX),(LABELS(16),IBDY),
     1    (LABELS(26),ITITLE),(LABELS(36),INFOX)
C              PROGRAM ORBPLOT WILL READ A TAPE GENERATED BY THE BATTERY
C         TEST PROGRAM AND PRODUCE PLOTS.  THE X AXIS ON ALL PLOTS
C         REPRESENTS ELAPSED TIME-MINUTES,  THE VARIOUS Y AXES ARE -
C            PLOT 1, GRID 1 - TEMP.3, DELTA Q, AND CURRENT - ALL STRINGS
C            PLOT 1, GRID 2 - VOLTAGES FOR CELLS 1,2,3     - ALL STRINGS
C            PLOT 2, GRID 1 - AUX. VOLTAGES CELLS 1,2,3    - STRINGS 3-9
C            PLOT 2, GRID 2 - PRESSURES FOR CELLS 1,2,3    - STRINGS 3-9
C            PLOT 3, GRID 1 - VOLTAGES-CELLS 4,5,6,7      - STRINGS 13-14
C            PLOT 3, GRID 2 - VOLTAGES-CELLS 8,9,10       - STRINGS 13-14
C            PLOT 4, GRID 1 - VOLTAGES-CELLS 11,12,13,14  - STRINGS 13-14
C            PLOT 4, GRID 2 - TEMP.3,4,AND 5 DATA        - STRINGS 13-14
C               CARD INPUTS REQUIRED TO EXECUTE THIS PROGRAM ARE -
C         CARD 0-INFOX(7-12)-INFO. FOR LINES 2 AND 3 OF PLOT HEADINGS
C                 INFOX(7-10)-16 COLUMNS- NO.1 THRU 16 FOR LINE NO. 2
C                 INFOX(11-12)-8 COLUMNS- NO.17 THRU 24 FOR LINE NO. 3
C         CARD 1-NRUNS- COL.1-2 (I2) - NUMBER OF RUNS ON TAPE
C                 (A RUN IS DEFINED BY A DOUBLE EOF)
C         CARD 2-ICON(1-6)-6 VALUES, 10 COLUMNS EACH (F10.5)-SCALE
C                 FACTORS WHICH ARE TO BE MULTIPLIED BY TAPE INPUT DATA
```

```
C              VALUES TO SCALE DATA FOR PLOTTING PURPOSES.
C                 ICON(1)- Q SCALE FACTOR
C                 ICON(2)- CURRENT SCALE FACTOR
C                 ICON(3)- VOLTAGE SCALE FACTOR
C                 ICON(4)- TEMPERATURE SCALE FACTOR
C                 ICON(5)- AUX. VOLTAGE SCALE FACTOR
C                 ICON(6)- PRESSURE SCALE FACTOR
C               CARDS 3-6 - PMAX AND PMIN FOR PLOT TYPES 1-4 - MAXIMUM AND
C                 MINIMUM Y AXIS VALUES FOR EACH OF THE 4 BASIC GRIDS - 2F10.5
C                 BASIC GRID 1-VOLTAGES(PLOT1-GRID2, PLOT3-GRID1, PLOT3-GRID2,
C                         PLOT4-GRID1)
C                 BASIC GRID 2-TEMP.DATA, DELTA Q, AND CURRENT(PLOT1-GRID1,
C                         PLOT4-GRID2)
C                 BASIC GRID 3-AUX. VOLTAGES(PLOT2-GRID1)
C                 BASIC GRID 4-PRESSURES(PLOT2-GRID2)
C               CARDS 7-N = IRUN,KORBIT,IORBIT, AND STRING ARRAY.
C                 IRUN- CCL.1-2(I2)-REQUESTED RUN TO BE PLOTTED.
C                       IF IRUN=0, PLOT ALL RUNS.  LAST CARD MUST HAVE IRUN=99
C                       FOR NORMAL PROGRAM TERMINATION.
C                 KORBIT- COL.11-15(I5)-INITIAL ORBIT NUMBER FOR IRUN.  IF
C                        KORBIT=0 OR 1, INITIAL ORBIT WILL BE ASSUMED TO BE
C                        1.
C                 IORBIT- COL.21-25(I5)-ORBIT TO BE PLOTTED WITHIN IRUN.
C                        IORBIT HAS NO MEANING IF IRUN=0.  IF IORBIT=0 ALL
C                        ORBITS WILL BE PLOTTED WITHIN IRUN.
C                 STRING ARRAY- COL.31-45(15I1)-STRINGS TO BE PLOTTED.
C                            ALTHOUGH THERE ARE 15 STRINGS AVAILABLE FOR
C                            PLOTTING, ONLY 10 STRINGS CAN BE PLOTTED DUE
C                            TO CORE STORAGE RESTRICTIONS.  IF MORE THAN 10
C                            ARE REQUESTED, THE FIRST 10 WILL BE PLOTTED.
C                            (IF USER REQUESTS STRINGS 1-15, ONLY STRINGS
C                            1-10 WILL BE PLOTTED).  IF REMAINING STRINGS
C                            ARE REQUIRED, JOB MUST BE RE-SUBMITTED.
C                            STRING IS REQUESTED BY PUNCHING -1- IN APPRO-
C                            PRIATE COLUMN.  (STRING1-COLUMN31.............
C                            ....STRING15-COLUMN45)
C               READ INFORMATION FOR PLOT HEADING
      READ(60,715)(INFOX(I),I=7,12)
  715 FORMAT(6A4)
C.........   READ CARD CONTAINING NO. OF RUNS ON TAPE
      READ(60,120)NRUNS
C.........   READ CARD CONTAINING CONVERSION CONSTANTS
      READ(60,121)(ICON(I),I=1,6)
C.........   READ CARDS CONTAINING MAX AND MIN PLOT VALUES (Y AXIS)
      DO 997 I=1,4
  997 READ(60,122)PMAX(I),PMIN(I)
C.........   INITIALIZE EOF COUNT, CALCULATED RUN AND ORBIT NUMBERS
      IEOF=0
      JRUN=1
      JORBIT=1
C.........   READ DESCRIPTOR RECORD FROM TAPE
      READ(10)(DESC(I),I=1,173)
      IF(EOFCKF(10).EQ.1)GO TO 998
      IF(SSWTCHF(1).EQ.1) WRITE(61,800) (DESC(I),I=1,173)
  800 FORMAT(20I5)
C.........   READ PAST EOF FOLLOWING RUN DESCRIPTOR RECORD
  996 READ(10)
      IF(EOFCKF(10).EQ.1)GO TO 998
      GO TO 996
C.........   READ RUN CARD
  998 READ(60,105)IRUN,KORBIT,IORBIT,STRING
  105 FORMAT(I2,8X,I5,5X,I5,5X,15I1)
```

```
      IF(IRUN.LT.JRUN.AND.IRUN.NE.0)GO TO 260
      IF(JORBIT.EQ.1.AND.KORBIT.NE.0)JORBIT=KORBIT
      IF(IRUN.EQ.99)STOP
      IF(IRUN.EQ.0)GO TO 999
      IF(IRUN.GT.JRUN)GO TO 130
  991 IF(IORBIT.EQ.0.OR.IORBIT.EQ.JORBIT)GO TO 999
  130 READ(10)(DATA(I),I=1,202)
      IF(EOFCKF(10).EQ.1)GO TO 140
      IEOF=0
      GO TO 130
  140 IEOF=IEOF+1
      IF(IEOF.EQ.2)GO TO 150
      JORBIT=JORBIT+1
  990 IF(IRUN.NE.JRUN)GO TO 130
      GO TO 991
  150 JRUN=JRUN+1
      IEOF=0
      JORBIT=KORBIT
      GO TO 990
  260 WRITE(61,261) IRUN,JRUN
  261 FORMAT(1H0,15HREQUESTING RUN ,I2,24H TAPE POSITIONED AT RUN ,I2)
      GO TO 998
C.........   READ DATA RECORD (J IS NUMBER OF ITERATIONS)
  999 J=0
 1000 READ(10)(DATA(I),I=1,202)
C.........   CHECK FOR EOF
      IF(EOFCKF(10).EQ.1)GO TO 50
      IF(SSWTCHF(1).EQ.1) WRITE(61,801) (DATA(I),I=1,202)
  801 FORMAT(1H ,10F12.6)
      IEOF=0
      J=J+1
C.........   CHECK FOR MAX ALLOWABLE ITERATIONS
      IF(J.GT.94)GO TO 85
      IT(3)=DATA(16)/10000.
      IT(4)=(DATA(16)-IT(3)*10000)/100.
      IF(J.EQ.1)IT(1)=DATA(16)/10000.
      IF(J.EQ.1)IT(2)=(DATA(16)-IT(1)*10000)/100.
      IXRAY(J)=J
C.........   LOOP TO ORDER ALL AVAILABLE DATA
      DO 200 IL=1,15
      DO 200 IM=1,3
  200 IY(IL,IM)=0
      IZ=IZZ=0
      DO 10 I=1,15
      IF(STRING(I).NE.1)GO TO 10
      IZZ=IZZ+1
      IF(IZZ.GT.10)GO TO 250
      IY(I,1)=IY(I,1)+1
C.........   STORE G DATA
      IQA=DATA(I)*ICON(1)
      IF(J.GT.1)GO TO 240
      IQ(J,IZZ)=0
      GO TO 241
  240 IQ(J,IZZ)=IGA-IQL(I)
  241 IQL(I)=IQA
C.........   STORE STRING CURRENTS, IF AVAILABLE
      IA=DESC(I)
      IF(IA.EQ.0)GO TO 1
      IA=IA+15
      IY(I,1)=IY(I,1)+1
      IAMP(J,IZZ)=DATA(IA)*ICON(2)
C.........   STORE STRING VOLTAGES AND TEMPERATURES, IF AVAILABLE
```

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```
    1 IF(I.LE.12)GO TO 902
      IF(I.GE.15)GO TO 902
      GO TO 4
  902 DO 3 K=1,3
      IA=I
      IF(IA.EQ.15)IA=13
      IB=IA*3+K+12
      IB=DESC(IB)
      IF(IB.EQ.0)GO TO 2
      IB=IB+15
      IY(I,1)=IY(I,1)+1
      IVOLTA(J,IZZ,K)=DATA(IB)*ICON(3)
    2 IF(K.NE.3)GO TO 3
      IB=IA*3+K+79
      IB=DESC(IB)
      IF(IB.EQ.0)GO TO 3
      IB=IB+15
      IY(I,1)=IY(I,1)+1
      ITEMPA(J,IZZ)=DATA(IB)*ICON(4)
    3 CONTINUE
      GO TO 7
C.........   STORE STRING VOLTAGES AND TEMPERATURES, IF AVAILABLE(13-14)
    4 IA=I-12
      DO 6 K=1,14
      IF(K.LT.3.OR.K.GT.5)GO TO 5
      KA=K-2
      IB=IA*5+K+116
      IB=DESC(IB)
      IF(IB.EQ.0)GO TO 5
      IB=IB+15
      IF(KA.EQ.1)IY(I,1)=IY(I,1)+1
      IF(KA.EQ.2.OR.KA.EQ.3)IY(I,3)=IY(I,3)+1
      ITEMPB(J,IA,KA)=DATA(IB)*ICON(4)
    5 IB=IA*14+K+40
      IB=DESC(IB)
      IF(IB.EQ.0)GO TO 6
      IB=IB+15
      IF(K.LT.4)IY(I,1)=IY(I,1)+1
      IF(K.GT.3.AND.K.LT.11)IY(I,2)=IY(I,2)+1
      IF(K.GT.10)IY(I,3)=IY(I,3)+1
      IVOLTB(J,IA,K)=DATA(IB)*ICON(3)
    6 CONTINUE
C.........   STORE STRING AUX. VOLTAGES AND PRESSURES, IF AVAILABLE(3-9)
    7 IF(I.LT.3.OR.I.GT.9)GO TO 10
      IA=I-2
      DO 9 K=1,3
      IB=IA*3+K+128
      IB=DESC(IB)
      IF(IB.EQ.0)GO TO 8
      IB=IB+15
      IY(I,2)=IY(I,2)+1
      IAUX(J,IA,K)=DATA(IB)*ICON(5)
    8 IB=IA*3+K+149
      IB=DESC(IB)
      IF(IB.EQ.0)GO TO 9
      IB=IB+15
      IZ=IZ+1
      IF(IZ.GT.6)GO TO 9
      IY(I,2)=IY(I,2)+1
      IPRESS(J,IZ)=DATA(IB)*ICON(6)
    9 CONTINUE
      GO TO 10
```

```
  250 WRITE(61,251)I
  251 FORMAT(1H0,44H10 STRINGS PROCESSED. CANNOT PROCESS S (ING KI2)
   10 CONTINUE
C..........   ALL DATA STORED FROM THIS RECORD. GET NEXT ONE
      GO TO 1000
C
C..........   EOF FOUND, END OF ORBIT, PLOT.
   50 IEOF=IEOF+1
C..........   IF DOUBLE EOF, RUN COMPLETED.
      IF(IEOF.EQ.2)GO TO 87
C..........   LOOP TO SET UP PLOT ARRAYS
      IZ=IZZ=0
      DO 300 IL=1,15
      DO 300 IM=1,3
  300 IX(IL,IM)=0
      DO 84 I=1,15
      IP11=IP21=IP31=IP41=IP12=IP22=IP32=IP42=0
      IF(STRING(I).NE.1)GO TO 84
      IZZ=IZZ+1
      IF(IZZ.GT.10)GO TO 84
      IF(J.EQ.94)GO TO 52
      JA=J+1
      DO 51 IA=JA,94
      IYRAY(IA)=0
   51 IXRAY(IA)=IA
C..........   STORE G DATA IN Y ARRAY
   52 DO 53 IA=1,J
   53 IYRAY(IA)=IQ(IA,IZZ)
      IX(I,1)=IX(I,1)+1
C..........   SET UP PLOT CALL VARIABLES
      IND=1
      IF(IX(I,1).EQ.IY(I,1))IND=2
      IP11=IP11+1
      INDPLOT=1
      NPLOT=2
      IGRID=1
      IPLOT=IP11
      N=-94
      L=1
      AMAXMIN(1)=IXRAY(1)+99
      AMAXMIN(2)=IXRAY(1)
      AMAXMIN(3)=PMAX(2)
      AMAXMIN(4)=PMIN(2)
      IAUTO=0
      LOG=0
      IE=0
      MT=0
      AXIS=0
      NC=48
      ENCODE(24,716,INFOX(1))
  716 FORMAT(24H100 AMP HR BATT TEST  1+)
      ENCODE (20,701,IDENT(1))ICON(1)
  701 FORMAT(4H    ,4HQ    ,4HSF.=,E8.5)
      ENCODE (40,702,IBDX(1)) IT(1),IT(2),IT(3),IT(4)
  702 FORMAT(2I4,4H    ,4H TIM,4HE - ,4HMINU,4HTES ,4H    ,2I4)
      ENCODE (32,705,IBDY(1))
  705 FORMAT(4H    ,4H   T,4HEMP.,4H3, C,4HURRE,4HNT, ,4HQ    ,4H    )
      ITITLE(1)=4HRUN
      ITITLE(2)=4HNC.
      ITITLE(3)=4HXX
      ITITLE(4)=4HORBI
      ITITLE(5)=4HT NO
```

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```
      ITITLE(6)=4H, XX
      ITITLE(7)=4H  ST
      ITITLE(8)=4HRING
      ITITLE(9)=4H XX
      ITITLE(10)=4H
      ENCODE(4,301,ITITLE(3))JRUN
  301 FORMAT(I2,2H  )
      ENCODE(4,302,ITITLE(6))JORBIT
  302 FORMAT(2H, ,I2)
      ENCODE(4,303,ITITLE(9))I
  303 FORMAT(1H ,I2,1H )
      IRET=1
      GO TO 81
C.........  STORE STRING AMP DATA IN Y ARRAY, IF AVAILABLE
   54 IB=DESC(I)
      IF(IB.EQ.0)GO TO 56
      IX(I,1)=IX(I,1)+1
      IP11=IP11+1
      DO 55 IA=1,J
   55 IYRAY(IA)=IAMP(IA,IZZ)
      IND=3
      IF(IX(I,1).EQ.IY(I,1))IND=2
      NPLOT=2
      IGRID=1
      IPLOT=IP11
      IRET=2
      ENCODE(20,304,IDENT(1))ICON(2)
  304 FORMAT(4HCURR,4HENT ,4HSF.=,E8.5)
      GO TO 81
C.........  STORE STRING TEMP 3 DATA IN Y.ARRAY, IF AVAILABLE
   56 IF(I.GT.12.AND.I.LT.15)GO TO 58
      IB=I
      IF(IB.EQ.15)IB=13
      IC=IB*3+82
      IC=DESC(IC)
      IF(IC.EQ.0)GO TO 60
      IX(I,1)=IX(I,1)+1
      IP11=IP11+1
      DO 57 IA=1,J
   57 IYRAY(IA)=ITEMPA(IA,IZZ)
      IND=3
      IF(IX(I,1).EQ.IY(I,1))IND=2
      NPLOT=2
      IGRID=1
      IPLOT=IP11
      IRET=3
      ENCODE(20,305,IDENT(1))ICON(4)
  305 FORMAT(4HTEMP,4H, 3 ,4HSF.=,E8.5)
      GO TO 81
C.........  STORE STRING TEMP 3 DATA (13-14)
   58 IB=(I-12)*5+119
      IC=I-12
      IB=DESC(IB)
      IF(IB.EQ.0) GO TO 60
      IX(I,1)=IX(I,1)+1
      IP11=IP11+1
      DO 59 IA=1,J
   59 IYRAY(IA)=ITEMPB(IA,IC,1)
      IND=3
      IF(IX(I,1).EQ.IY(I,1))IND=2
      NPLOT=2
      IGRID=1
```

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```
      IPLOT=IP11
      IRET=4
      ENCODE(20,305,IDENT(1))ICON(4)
      GO TO 81
C.........  STORE VOLTAGE DATA FOR GRID NO. 2 (1-12,15) PLCT 1
   60 IF(I.GT.12.AND.I.LT.15)GO TO 63
      DO 62 K=1,3
      IA=I
      IF(IA.EQ.15)IA=13
      IB=IA*3+K+12
      IB=DESC(IB)
      IF(IB.EQ.0) GO TO 62
      IX(I,1)=IX(I,1)+1
      IP12=IP12+1
      DO 61 ID=1,J
   61 IYRAY(ID)=IVOLTA(ID,IZZ,K)
      IND=3
      IF(IX(I,1).EQ.IY(I,1)) IND=2
      NPLOT=2
      IGRID=2
      IPLOT=IP12
      IRET=5
      AMAXMIN(3)=PMAX(1)
      AMAXMIN(4)=PMIN(1)
      ENCODE(20,306,IDENT(1)) K,ICON(3)
  306 FORMAT(4HVOLT,1H ,I2,1H ,4HSF.=,E8.5)
      ENCODE(32,307,IBDY(1))
  307 FORMAT(4H    ,4H CEL,4HL VO,4HLTAG,4HES 1,4H,2 A,4HND 3,4H    )
      GO TO 81
   62 CONTINUE
      GO TO 66
C.........STORE VOLTAGE DATA FOR GRID NO. 2 (13-14)
   63 DO 65 K=1,3
      IA=I-12
      IB=IA*14+K+40
      IB=DESC(IB)
      IF(IB.EQ.0) GO TO 65
      IX(I,1)=IX(I,1)+1
      IP12=IP12+1
      DO 64 ID=1,J
   64 IYRAY(ID)=IVOLTB(ID,IA,K)
      IND=3
      IF(IX(I,1).EQ.IY(I,1))IND=2
      NPLOT=2
      IGRID=2
      IPLOT=IP12
      IRET=6
      AMAXMIN(3)=PMAX(1)
      AMAXMIN(4)=PMIN(1)
      ENCODE(20,306,IDENT(1)) K,ICON(3)
      ENCODE(32,307,IBDY(1))
      GO TO 81
   65 CONTINUE
   66 IF(I.LT.3.OR.I.EQ.15)GO TO 84
      IF(I.GT.9.AND.I.LT.13)GO TO 84
C.........  PROCESS STRING 3-9
      IF(I.GT.9) GO TO 72
      IA=I-2
      IG=0
      DO 68 K=1,3
      IB=IA*3+K+128
      IB=DESC(IB)
```

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```
      IF(IB.EQ.0)GO TO 68
      IX(I,2)=IX(I,2)+1
      IP21=IP21+1
      DO 67 ID=1,J
   67 IYRAY(ID)=IAUX(ID,IA,K)
      IND=3
      IF(IX(I,2).EQ.IY(I,2)) IND=2
      IF(IX(I,2).EQ.1)IND=1
      NPLOT=2
      IGRID=1
      IPLOT=IP21
      IRET=7
      AMAXMIN(3)=PMAX(3)
      AMAXMIN(4)=PMIN(3)
      ENCODE(20,308,IDENT(1))K,ICON(5)
  308 FORMAT(4HAUX.,1H ,I2,1H ,4HSF.=,E8.5)
      ENCODE(32,309,IBDY(1))
  309 FORMAT(4H  CE,4HLLS ,4H1,2 ,4HAND ,4H3 AU,4HX VO,4HLTAG,4HES  )
      GO TO 81
   68 CONTINUE
      DO 70 K=1,3
      IB=IA*3+K+149
      IB=DESC(IB)
      IF(IB.EQ.0) GO TO 70
      IZ=IZ+1
      IF(IZ.GT.6) GO TO 70
      IX(I,2)=IX(I,2)+1
      IP22=IP22+1
      DO 69 ID=1,J
   69 IYRAY(ID)=IPRESS(ID,IZ)
      IND=3
      IF(IX(I,2).EQ.IY(I,2))IND=2
      IF(IX(I,2).EQ.1) IND=1
      NPLOT=2
      IGRID=2
      IPLOT=IP22
      IRET=8
      AMAXMIN(3)=PMAX(4)
      AMAXMIN(4)=PMIN(4)
      ENCODE(20,310,IDENT(1))K,ICON(6)
  310 FORMAT(4HPRES,1H ,I2,1H ,4HSF.=,E8.5)
      ENCODE(32,311,IBDY(1))
  311 FORMAT(4H    ,4HCELL,4HS 1,,4H2 AN,4HD 3 ,4HPRES,4HSURE,4HS   )
      GO TO 81
   70 CONTINUE
      GO TO 84
C.........   STORE VOLTAGE AND TEMP DATA FOR STRINGS 14-15
   72 IA=I-12
      DO 74 K=4,7
      IB=IA*14+K+40
      IB=DESC(IB)
      IF(IB.EQ.0) GO TO 74
      IX(I,2)=IX(I,2)+1
      IP31=IP31+1
      DO 73 ID=1,J
   73 IYRAY(ID)=IVOLTB(ID,IA,K)
      IND=3
      IF(IX(I,2).EQ.IY(I,2))IND=2
      IF(IX(I,2).EQ.1) IND=1
      NPLOT=2
      INDPLOT=1
      IF(K.EQ.7) INDPLOT=2
```

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```
      IGRID=1
      IPLOT=IP31
      IRET=9
      AMAXMIN(3)=PMAX(1)
      AMAXMIN(4)=PMIN(1)
      ENCODE(20,306,IDENT(1))K,ICON(5)
      ENCODE(32,312,IBDY(1))
  312 FORMAT(4H   C,4HELL ,4HVOLT,4HAGES,4H 4,5,4H,6 A,4HND 7,4H    )
      GO TO 81
   74 INOPLOT=1
      DO 76 K=9,10
      IB=IA*14+K+40
      IB=DESC(IB)
      IF(IB.EQ.0) GO TO 76
      IX(I,2)=IX(I,2)+1
      IP32=IP32+1
      DO 75 ID=1,J
   75 IYRAY(ID)=IVOLTB(ID,IA,K)
      IND=3
      IF(IX(I,2).EQ.IY(I,2)) IND=2
      IF(IX(I,2).EQ.1) IND=1
      NPLOT=2
      INDPLOT=1
      IF(K.EQ.10) INOPLOT=2
      IGRID=2
      IPLOT=IP32
      IRET=10
      AMAXMIN(3)=PMAX(1)
      AMAXMIN(4)=PMIN(1)
      ENCODE(20,306,IDENT(1))K,ICON(5)
      ENCODE(32,313,IBDY(1))
  313 FORMAT(4H    ,4HCELL,4H VOL,4HTAGE,4HS 8,,4H9, A,4HND 1,4H0    )
      GO TO 81
   76 INOPLOT=1
C..........   STORE VOLTAGE AND TEMP DATA FOR STRINGS 14-15
      DO 78 K=11,14
      IB=IA*14+K+40
      IB=DESC(IB)
      IF(IB.EQ.0) GO TO 78
      IX(I,3)=IX(I,3)+1
      IP41=IP41+1
      DO 77 ID=1,J
   77 IYRAY(ID)=IVOLTB(ID,IA,K)
      IND=3
      IF(IX(I,3).EQ.IY(I,3)) IND=2
      IF(IX(I,3).EQ. 1)IND=1
      NPLOT=2
      IGRID=1
      IPLOT=IP41
      IRET=11
      AMAXMIN(3)=PMAX(1)
      AMAXMIN(4)=PMIN(1)
      ENCODE(20,306,IDENT(1))K,ICON(5)
      ENCODE(32,314,IBDY(1))
  314 FORMAT(4H CEL,4HL VO,4HLTAG,4HES 1,4H1,12,4H,13,,4H AND,4H 14 )
      GO TO 81
   78 CONTINUE
      DO 80 K=1,3
      IB=IA*5+119
      IB=DESC(IB)
      IF(IB.EQ.0)GO TO 80
      IX(I,3)=IX(I,3)+1
```

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      IP42=IP42+1
      DO 79 ID=1,J
   79 IYRAY(ID)=ITEMPB(ID,IA,K)
      KA=K+2
      IND=3
      IF(IX(I,3).EQ.IY(I,3))IND=2
      IF(IX(I,3).EQ.1) IND=1
      NPLOT=2
      IGRID=2
      IPLOT=IP42
      IRET=12
      AMAXMIN(3)=PMAX(2)
      AMAXMIN(4)=PMIN(2)
      ENCODE(20,315,IDENT(1))KA,ICON(4)
  315 FORMAT(4HTEMP,1H.,I2,1H ,4HSF.=,I4,4H    )
      ENCODE(32,316,IBDY(1))
  316 FORMAT(4H  TE,4HMP.3,4H, TE,4HMP.4,4H AND,4H 5  ,4H    ,4H    )
      GO TO 81
   80 CONTINUE
      GO TO 84
   81 CALL STPPS(INC,NPLOT,INDPLOT,IGRID,IPLOT,N,IXRAY,IYRAY,L,AMAXMIN,
     1IAUTO,LOG,IE,MT,AXIS,NC,LABELS)
      IF(NPLOT.NE.0) GO TO 82
      GO TO (54,56,60,60,62,65,68,70,74,76,78,80) IRET
   82 WRITE(61,83)NPLOT,IRET
   83 FORMAT(1H0,6HNPLOT=,I5,5HIRET=,I5)
      GO TO (54,56,60,60,62,65,68,70,74,76,78,80) IRET
   84 CONTINUE
      GO TO 88
C.........   NO. OF ITERATIONS EXCEEDS 100, SKIP TO END OF ORBIT
   85 J=94
   86 READ(10)(DATA(I),I=1,202)
      IF(EOFCKF(10).EQ.1) GO TO 50
      GO TO 86
C.........   END OF RUN PROCESSING
   87 IEOF=0
      JORBIT=1
      JRUN=JRUN+1
      IF(JRUN.GT.NRUNS) STOP
      IF(IRUN.EQ.0) GO TO 999
      GO TO 998
   88 JORBIT=JORBIT+1
      IF(IORBIT.EQ.0) GO TO 999
      GO TO 998
  120 FORMAT(I2)
  121 FORMAT(6F10.5)
  122 FORMAT(2F10.5)
      END
```

PROGRAM VARIABLES

00515	R	AXIS	00543	I	IG	00472	I	IP21	00422	I	IRUN	00423	I	KORBIT
00404	I	I	00505	I	IGRID	00476	I	IP22	00444	I	IZ	00510	I	L
00447	I	IA	00437	I	IL	00473	I	IP31	00445	I	IZZ	00512	I	LOG
00511	I	IAUTO	00441	I	IM	00477	I	IP32	00430	I	J	00514	I	MT
00452	I	IB	00502	I	IND	00474	I	IP41	00501	I	JA	00507	I	N
00537	I	IC	00503	I	INDPLOT	00500	I	IP42	00416	I	JORBIT	00517	I	NC
00542	I	ID	00424	I	IORBIT	00506	I	IPLOT	00415	I	JRUN	00504	I	NPLOT
00513	I	IE	00471	I	IP11	00446	I	IQA	00450	I	K	00407	I	NRUNS
00413	I	IEOF	00475	I	IP12	00536	I	IRET	00457	I	KA			

COMMON VARIABLES

```
00624 R    AMAXMIN     27365 I    IBDY        27736 I    IQL         04410 I    IVOLTA      27174 I    IYRAY
00000 R    DATA        27332 R    ICON        00654 I    IT          13670 I    IVOLTB      27346 I    LABELS
27425 I    DESC        27346 I    IDENT       12014 I    ITEMPA      27706 C    IX          00634 R    PMAX
02534 I    IAMP        27411 I    INFOX       21000 I    ITEMPB      27036 I    IXRAY       00644 R    PMIN
22064 I    IAUX        25752 I    IPRESS      27377 I    ITITLE      27722 C    IY          27702 C    STRING
27353 I    IBDX        00660 I    IQ

     STATEMENT NUMBERS

       1 01704         56 03112         73 04275        105 00004        302 00131        701 00063
       2 01775         57 03167         74 04403        120 00376        303 00134        702 00072
       3 02042         58 03240         75 04450        121 00377        304 00137        705 00107
       4 02053         59 03276         76 04556        122 00401        305 00146        715 00000
       5 02157         60 03347         77 04623        130 01310        306 00155        716 00053
       6 02252         61 03427         78 04720        140 01341        307 00165        800 00002
       7 02262         62 03514         79 04763        150 01364        308 00204        801 00031
       8 02340         63 03525         80 05064        200 01547        309 00214        902 01721
       9 02411         64 03565         81 05075        240 01644        310 00233        990 01355
      10 02430         65 03652         82 05153        241 01651        311 00243        991 01277
      50 02441         66 03662         83 00367        250 02422        312 00262        996 01200
      51 02556         67 03754         84 05210        291 00035        313 003C1        997 01075
      52 02570         68 04051         85 05221        260 01374        314 00320        998 01213
      53 02572         69 04127         86 05224        261 00012        315 00337        999 01405
      54 03015         70 04224         87 05253        300 02463        316 00350       1000 01410
      55 03041         72 04235         88 05300        301 00126

     EXTERNAL REFERENCES

          EOFCKF              SSWTCHF              STPPS

               FORTRAN DIAGNOSTIC RESULTS  FOR    OBRPLOT

   COMPILED LENGTHS OF OBRPLOT  - P   05317   C   27755   D   00000
NO ERRORS
FORTRAN,I=2,L,N

                         MS FORTRAN (4.2)/MSOS             07/13/73

          FINIS                                                        00577
          FINIS

               FORTRAN DIAGNOSTIC RESULTS  FOR    OZ7WOZ7W

I FTNC 0514 DETECTED AT      1 STATEMENT  BEYOND STATEMENT NO.     0
 CANNOT IDENTIFY STATEMENT TYPE.  STATEMENT NAME MISSPELLED OR MISUSED OR AN EQUAL SIGN IS MISPLACED.
U FTNC 5013 I/O ERROR END OF FILE ON FILE 02
```

Card inputs for the BDR are split into three groups

GROUP I - TEST VARIABLES

Card 1 - This card allows the user to define the test I.D., input tape record size. Minimum expected returns, position of discharge flag and up to six starting orbit nos.

a) Columns 1 to 20 are used for a 20 character alphanumeric ID. This ID is printed on every page of output and is passed onto the plot program for labelling.

b) Columns 21 to 24 right justified in this field is the number of twelve (12) character words per physical input tape record. NOTE: Each record read is verified for this length if the actual length does not agree with this length. The record is skipped over and an error message is printed, however processing continues.

c) Columns 25 to 30 and 31-35. In these two fields the user supplies the minimum amp. percentage return and WATT-return respectively. These figures are percentages and must contain a decimal point. Further, the user is provided an error message each time the respective quantities fall below these levels.

d) Columns 37 to 40. This integer number allows the user to redfine the data <u>word position</u> for the discharge flag it must be right justified.

e) Columns 41 to 45, 46 to 50, 51 to 55, 56 to 10, 61 to 65, 66 to 70. Provide the user to start the orbit counter at this integer number for input files 1 to 6 respectively. (NOTE: Even if the user wishes each run to start at one. This card must say one)

GROUP II - STRING VARIABLES

This group of cards allows the user to specify measured switch-over volts vs. temp relations, the flow rate, and ambient temperature differential for each string. One card is required for each active string and the last card of this group must contain a zero in column five (5). This notifies the program to go on to Group III.

a) Columns 1 to 5. Contain the string no. (J) which this card defines. (NOTE: Zero flags end of this group)

b) Columns 6 to 45, VOLTS AT POINT 1 6 degrees F at point 1, volts at point 2 and degrees F at point 2 respectively. Each field is read in the same format four digits to the left of the decimal point, the decimal point and five digits to the right of the decimal point. The BDR program uses these numbers to compute the slope and intercept for string J of the temperature dependence curve for a single cell switchover voltage.

GROUP II (cont'd)

c) Columns 46 to 55 specify the flow rate in LBS/hr. The BDR program converts this to a constant (watt-hrs/degrees F) by multiplying it by .0048804 for string J. It is read in the same format as the above quantities.)

d) Columns 56 to 65 specify the ambient (degrees F) temperature correction to be used in the computation of Q for string J. It is printed out with Q at the end of each orbit.

GROUP III - CHANNEL ASSIGNMENTS

This group of cards allows the user to specify the channel no. associated with every variable involved in a test. The BDR distinguishes variables by string no. and cell no. (or subset no. in the case of temperatures). The BDR has been set up to recognize five types of variables - string currents (I), temperatures (T), cell voltages (V), auxillary voltages (A), and pressures (P). Further, two control characters (C, *) allow the user to control the reading of the channel assignment cards. The BDR searches the first data record for each requested channel and sets up a descriptor array with the associated word position of each parameter. This array is used to extract the defined types of measurements from the input tape record by the BDR. Further, the BDR passes this descriptor onto the plot program as the first record of the intermediate plot tape. Therefore, the success of both programs is highly dependent upon the proper definition of all data variables and accordingly, the BDR has been constructed to verify these cards for allowable requests only. Any detectable error will inhibit reduction and the user will be provided with an error description. A summary of the possible errors is listed at the end of this section. The table below lists the restrictions with each variable type.

TABLE 1.0

	Allowable Strings	Maximum no. of Cells or subsets	Max Total
I	1 to 15	1	15
T	1 to 12	3	36
	13 to 14	5	10
	15	3	3
V	1 to 12	3	36
	13 to 14	14	28
	15	3	3
A	3 to 9	3	21
P	3 to 9	3	21
			173

The time, alarm word and julian day are fixed to data words one and two and second channel no. The discharge flag is defined by Group I.

Each channel assignment card (CAC) contains the following information in thirteen fields as defined below.

FIELD 1 String no. J (columns 1 to 2) the first and last CAC contain the first and last active string respectively and therefore the user must organize the CAC's in string ascending order.

FIELD 2 (NC) number of cells for string J (columns 3 and 4) this quantity specifies the last cell used in string J. For example, if cells 1, 2, and 9 are connected for string J NC must be 9 not 3.

FIELDS 3-12 These fields occupy columns

3 -	6 to 11	8 -	41 to 46
4 -	13 to 18	9 -	48 to 53
5 -	20 to 25	10 -	55 to 60
6 -	27 to 32	11 -	62 to 67
7 -	34 to 39	12 -	69 to 74

Each of these fields is set up as below:

CCCTNN

WHERE: CCC = three-digit numeric channel no.
T = one alphanumeric character for measurement type A CAC control.
NN = Two-digit numeric cell no. or subset no. Note: NN must be 01 for every string current assignment.

The allowable T and action taken is listed below:

- I - Assign string current for string J
- T - Assign temp for string J, subset NN
- V - Assign cell volt for string J, cell NN
- A - Assign aux volt for string J, cell NN
- P - Assign pressure for string J, cell NN
- C - No assignment - Last field on this card
- * - No assignment - Last card this string no. J on this card is the last active string. NC must also appear for string J.

ANY OTHER - Error

Note: Blanks are allowable for T only if the previous field on the CAC contained A C or *.

FIELD 13 (M) card no. (columns 79 to 80). This number is an aid to maintain the sequential order of CAC's and is printed out to identify any error on card M.

Error Conditions Detected

1. A table internal to the BDR program has been constructed with all 173 possible combinations of measurement type, string no, subset no. as shown in Table 1.0. If the user requests assignment for a parameter not contained in this table is flagged an error. For example, string J = 2 CCC = 070 T = A NN = 01 is not allowable since aux. voltages are only allowed on strings 3 thru 9.

FIELD 13 (cont'd)

2. If *CCC* is not a channel no. contained on the input tape the associated parameter is undefined and is in error.

3. If *CCC* has been previously defined by another CAC field. The channel is doubly defined and is in error.

4. If *T* is not an allowable character that field is in error.

DECK SETUP AND DESCRIPTION OF PROGRAM ORBPLOT

DESCRIPTION: PROGRAM ORBPLOT WILL READ A TAPE GENERATED BY THE BATTERY TEST PROGRAM AND PRODUCE PLOTS. THE X AXIS ON ALL PLOTS REPRESENTS ELAPSED TIME - MINUTES. THE VARIOUS Y AXES ARE:

PLOT 1, GRID 1	TEMP. 3, DELTA Q, AND CURRENT	ALL STRINGS
PLOT 1, GRID 2	VOLTAGES FOR CELLS 1,2,3	ALL STRINGS
PLOT 2, GRID 1	AUX. VOLTAGES, CELLS 1,2,3	STRINGS 3-9
PLOT 2, GRID 2	PRESSURES, CELLS 1,2,3	STRINGS 3-9
PLOT 3, GRID 1	VOLTAGES, CELLS 4,5,6,7	STRINGS 13-14
PLOT 3, GRID 2	VOLTAGES, CELLS 8,9,10	STRINGS 13-14
PLOT 4, GRID 1	VOLTAGES, CELLS 11,12,13,14	STRINGS 13-14
PLOT 4, GRID 2	TEMP. 3,4, AND 5	STRINGS 13-14

CARD 0 INFOX (7-12) INFORMATION FOR LINES 2&3 OF PLOT HDG

DECK SETUP

CARD 1 - NRUNS - COL. 1-2 (I2) - NUMBER OF RUNS ON TAPE. (A RUN IS DEFINED BY A DOUBLE EOF)

CARD 2 - SCALE FACTORS - 6 VALUES WITH DECIMAL POINTS, EACH VALUE USING 10 COLUMNS. THESE VALUES WILL BE MULTIPLIED BY TAPE INPUT DATA TO SCALE DATA FOR PLOTTING PURPOSES.

- COL. 1-10 - Q SCALE FACTOR
- COL. 11-20 - CURRENT SCALE FACTOR
- COL. 21-30 - VOLTAGE SCALE FACTOR
- COL. 31-40 - TEMPERATURE SCALE FACTOR
- COL. 41-50 - AUX. VOLTAGE SCALE FACTOR
- COL. 51-60 - PRESSURE SCALE FACTOR

CARDS 3-6 MAXIMUM AND MINIMUM VALUES FOR Y AXIS. THESE VALUES SHOULD REFLECT MAGNITUDE OF DATA AFTER SCALE FACTORS HAVE BEEN APPLIED. COL. 1-10 WILL CONTAIN THE MAXIMUM VALUE WITH DECIMAL POINT AND COL. 11-20 WILL CONTAIN THE MINIMUM VALUE WITH DECIMAL POINT. THERE ARE FOUR BASIC GRIDS AND ONE CARD MUST ALWAYS BE PRESENT FOR EACH GRID. THESE BASIC GRIDS ARE:

1- (CARD 3) - VOLTAGES (PLOT 1-GRID 2, PLOT 3-GRID 1, PLOT 3-GRID 2, PLOT 4-GRID 1)
2- (CARD 4) - TEMP. DATA, DELTA Q, AND CURRENT (PLOT 1-GRID 1, PLOT 4-GRID 2)
3- (CARD 5) - AUX. VOLTAGES (PLOT 2-GRID 1)
4- (CARD 6) - PRESSURES (PLOT 2-GRID 2)

CARDS 7-N - RUN CARDS. A RUN CARD MUST BE PRESENT FOR EACH RUN TO BE PLOTTED. CONTAINED ON EACH RUN CARD WILL BE THE FOLLOWING INFORMATION:

REQUESTED RUN NUMBER - COL. 1-2 (RIGHT JUSTIFIED; i.e, RUN 1 SHOULD APPEAR A 01). IF ALL RUNS ARE NEEDED, REQUESTED RUN NUMBER SHOULD BE 00; PROGRAM WILL AUTOMATICALLY PROCESS ALL RUNS ON TAPE. IN ORDER FOR PROGRAM TO TERMINATE NORMALLY, LAST RUN CARD, FOLLOWING LAST REQUESTED RUN CARD MUST CONTAIN 99 IN COL 1-2.

INITIAL ORBIT NUMBER WITHIN RUN - COL. 11-15 (RIGHT JUSTIFIED) IDENTIFIES FIRST RECORDED ORBIT WITHIN RUN. ASSUMED TO BE 1 IF SPECIFIED AS 0 OR 1.

REQUESTED ORBIT TO BE PLOTTED - COL. 21-25 (RIGHT JUSTIFIED) IF REQUESTED ORBIT IS 0, PROGRAM WILL AUTOMATICALLY PLOT ALL ORBITS WITHIN REQUESTED RUN. IF REQUESTED RUN NUMBER IS 0, REQUESTED ORBIT NUMBER HAS NO MEANING.

STRINGS TO BE PLOTTED - COL. 31-45 (ONE COLUMN FOR EACH STRING). ALTHOUGH THERE ARE 15 STRINGS AVAILABLE FOR PLOTTING, ONLY 10 STRINGS CAN BE PLOTTED FOR EACH RUN DUE TO STORAGE RESTRICTIONS. IF MORE THAN 10 ARE REQUESTED, ONLY THE FIRST 10 WILL BE PLOTTED. (IF USER REQUESTS STRINGS 1 THRU 15 ONLY STRINGS 1 THRU 10 WILL BE PLOTTED). IF REMAINING STRINGS ARE REQUIRED, JOB MUST BE RE-SUBMITTED. STRING IS REQUESTED BY PUNCHING 1 IN APPROPRIATE COLUMN. (STRING 1 - COLUMN 31 ...... STRING 15 - COLUMN 45)

AVOID VERBAL ORDERS

APPENDIX R-1

FROM: M. Wertheim | POD/553 | 35 | X9142 | DATE 8 January 1973
NAME | GROUP NO. & NAME | PLANT NO. | EXT.

TO: S. Gaston, Project Engineer | NO. D559-3-1

SUBJECT: PARAMETRIC/LIFE CYCLE TESTS --------
INSTRUCTIONS FOR SETUP AND OPERATION

REFERENCE: a) NAS9-11074

b) Monthly Progress Report, October 1972, Appendix 1

ENCLOSURE: PARAMETRIC/LIFE CYCLE TESTS ......OUTLINE INSTRUCTIONS

The enclosed document, an outline of instructions to set up, prepare for and run parametric cell and life tests, is herewith released for use by laboratory personnel. This document supersedes and replaces the one previously issued unofficially, and attached to the October, 1972 Monthly Progress Report as Appendix 1 (Reference b).

MW/gms

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APPENDIX R

PARAMETRIC/LIFE CYCLE

TESTS

ENCLOSURE 1

PARAMETRIC/LIFE CELL TESTS - OUTLINE INSTRUCTIONS

I. VISUAL INSPECTION AND CELL/GAUGE ASSEMBLY

A. Cells will be received with gauges dismounted. Assure the following:

1. Terminals straight, clean, free of visible damage around seals or ceramic.

2. Cover weld clean and without visible flaw.

3. No excess bulging or concavity of cell sides, faces, cover or bottom.

4. Serial number clearly visible on cell. Cell weight data clearly visible. Record all these data.

5. Shorting wire in place and tight. Auxiliary electrode tab (if used) near negative terminal.

6. Correlation data available to show which gauge was used with which cell.

7. Record all inspection discrepancies. Take polaroid photos of any large (major) defects.

B. Inspect gauges as received. Assure the following:

1. Each gauge contains the necessary information to show on which cell it is to be used.

2. No visible damage is indicated.

3. Dial is zeroed at 0 PSIG $\pm$ 1 PSIG.

C. Remove Tee-connected valve, and install and calibrate safety switch to close at 85 PSIG $\pm$ 3 PSIG dial indication.

D. Re-connect Tee, and install on cell as follows:

1. Cells have been back-filled with dry nitrogen. Place in glove bag. Evacuate bag and back-fill with dry nitrogen to 1 atmosphere. Remove fill tube plugs. Install gauges.

2. Remove cell/gauge assemblies from glove bag. Evacuate each through valve. After closing valve and removing from vacuum pump, allow assembly to stand 24 hours in room pressure (STP), and assure that dial shows maintenance of internal vacuum.

3. If cell internal vacuum is not maintained, tighten gauge/Tee/valve/cell assembly and/or seal using "Torr Seal" epoxy resin. Evacuate again, and again allow to stand 24 hours to show vacuum retention. Repeat as required.

4. Should leakage show around terminal seal or cover weld, notify S. Gaston or M. Wertheim at once to prepare for possible cell rejection and return to seller.

II. TEST STRING ASSEMBLY

A. Deburr cover welds and can bottoms.

B. Deburr and round corners and edges of restraining hardware.

C. Wrap each cell ---- all faces except top --- in Kapton sheet. Overlap sheet around cover weld seam to provide smooth, clean interface to restraining plate edges. Tape edges and corners of restraining plates (P/N 559-111AV) with Kapton tape. Mark cell S/N on top surface with epoxy paint or other alkaline-resistant material.

D. Each test string shall consist of the following, as required by detailed instructions:

1. One (1) 2-Cell String (Assembly Drawing 559-117-AV, supplied for information only).

2. One (1) 3-Cell String (Assembly Drawing 559-112-AV, supplied for information only).

3. Two (2) 5-Cell Strings (Assembly Drawing 559-116-AV, supplied for information only).

E. Each 2-cell and each 3-cell string shall contain one (1) only temperature sensing resistor (TSR), P/N RdF BN-200. Each 5-cell string shall contain two (2) TSR's. TSR's shall be mounted on P/N 559-111AV-3 restraining plates only, and each shall be assembled with a standard gauge copper-constantan thermocouple TSR's shall be mounted between cells on the 2-cell strings, against the center cell on the 3-cell strings, and against both sides of the center cell on the 5-cell string.

F. Thermocouples shall also be installed to sense coolant inlet and coolant outlet temperatures of each test string (as defined in D above).

III. ASSEMBLY TO TEST POSITION

A. Connect test string coolant inlet and outlet tubes to designated coolant bath such that each test string operates in parallel with every other string on that bath. (For 10-Cell Test String ...... II. D above ..... two (2) 5-Cell string assemblies are connected as a test string to the bath.) Each test string flow rate shall be individually adjustable and set in accordance with the tables of AVO D559-2-22, 5/19/72. Operate coolant flow until no leakage is observed.

B. Connect electrical wiring to test controller, barrier strips and fuse strips as appropriate. TSR shall be connected to test controller. (For 10-Cell Test string, connect TSR's on each 5-Cell assembly in parallel, and connect each 5-Cell pair in series with the other pair. The series-parallel combination shall be connected to the test controller.) Electrical connections shall provide the capability to measure (but shall not necessarily all be measured and recorded) the following:

1. Each cell voltage.
2. Each auxiliary electrode voltage (across designated load resistor)
3. Each string current
4. Each TSR temperature
5. Each test string coolant inlet temperature
6. Each test string coolant outlet temperature

Each test position shall have the following additional data points:

1. String fault flag
2. Cell voltage over/under voltage scan

One test position on each coolant bath shall provide a charge/discharge flag such that, during discharge, the flag shall be high.

C. After completion of A and B above, and verification that all connections are good, insulate each string assembly using a polystyrene foam box whose cover leaves the pressure gauges free. Each box shall contain sufficient dessicant to absorb all moisture due to cooling. Each box shall be packed with "Vermiculite" material to assure minimum heat loss by convection or radiation. Each gauge shall be covered with a transparent plastic bag, taped tight to the box cover.

V. CONDITIONING AND CAPACITY DISCHARGE

A. Set up each string coolant flow and inlet temperature in accordance with III A. above.

B. Disconnect current program leads running from rack TB1-1 and TB1-2 to power supply (SRL-10-100) TB2-8 and TB2-7 at power supply. Reconnect link on power supply TB2-7 to TB2-8. Remove "S.U.T." leads from front of rack and replace with power shorting link. Energize rack and manually place in charge mode. Energize power supply. Set current, using front panel controls, to 10.0 ± 0.1 Ampere as verified by DAS printout. Shut down power supply and rack. Remove power shorting link and replace "S.U.T." leads.

C. Verify that all DAS and Bristol Recorder inputs from each string are connected and reading. Set up DAS magnetic tape to record every minute, and printer to read every 6 minutes. Bristol recorders shall scan at normal rate, and charts shall run at 3-4 divisions/4-5 minutes. Correlate time between data systems. Assure that sufficient paper is in each machine for 16-hour run.

D. Hand record the following data:

1. Time
2. Each cell voltage (may be read off DAS printed tape)
3. Each string current (may be read off DAS printed tape)
4. Each pressure gauge reading in <u>PSIG</u>

Record data before test is started (zero current) every 12 minutes the first hour, and every hour thereafter. Record final data just before string shut-down (from last DAS reading).

E. In what follows do <u>not</u> operate timing pulse power supply, fault power supply or cell voltage scanner (fault unit). If required, bypass the interlock contacts for these items in the master control.

F. Turn on all test positions (racks and power supplies) in charge mode. Allow strings to charge at the 10.0-Ampere rate to the following limits:

1. First cell in a string reaches 1.51 volts.
2. First cell in a string reach +50 PSIG.
3. 16 hours total is accumulated.

For the first two limits, the string to which either applies shall be shut down when either occurs. For the last, all strings then remaining shall be shut down.

NOTE: Conditioning charge shall be run as a continuous test.

G. After the first hour of conditioning charge, the DAS printer may be set to print every 30 minutes until the first cell comes to 1.490 volts. The DAS printer shall then be set on 1/minute print to catch the voltage limit. If there is wide separation among strings, the DAS printer may be set back to longer print intervals after each voltage limit has been reached, and the appropriate string has been turned off.

H. Within not more than 2 hours after last string has completed conditioning charge, the following steps shall be accomplished:

1. Discharge load resistors shall be configured for 30% DOD (i.e., one (1) 0.120-ohm resistor in series).

2. Power supply links on TB2-7 and TB2-8 shall be removed, and rack current program leads replaced. Front panel current controls must be set to zero (fully counter-clockwise).

3. Place 30% DOD sub-boards in all racks, board 3. Switches on board 2 shall be in "nominal" (L2) position.

4. With "S.U.T." leads removed from front of racks, and replaced by power shorting leads, verify, using DAS printer, that discharge mode current is 50 $\pm$ 3 Amperes (25 $\pm$ 1.5 millivolts). Then restore "S.U.T." leads.

I. Turn on all test positions in discharge mode. Have DAS printer operating 1/minute until last cell voltage drops below 1.290 volts, then raise interval to 1/12 minutes. When first cell reaches 1.100 volts, decrease interval to 1/minute again. Hand record data per D. above, except that readings shall be taken every 12 minutes throughout until first cell reaches 1.000 volt. Then record time to 1.000 volt, and to first cell reaching 0.900 volt. As soon as the first cell in a string reaches 0.900 volt, manually transfer that string to charge mode for taper charge prior to capacity check.

J. Taper charge by allowing test controller to step-current charge string(s) through each rate, operating from the temperature-compensated voltage limit (L2----"nominal"----is used; see H 3. above). Record data every 24 minutes. Allow each string to reach trickle level. When last string has been at trickle rate for 1 hour, transfer all strings to discharge, and repeat I. above and then repeat this procedure (J.), except that after last string has been at trickle rate for 1 hour, shut off all strings.

<u>NOTE:</u> If, during either taper charge, any cell in a string exceeds + 50 PSIG, that string shall be shut down until all strings are ready for the next step.

VI. <u>ORBITAL CYCLING</u>

A. Set up discharge load resistors and board 3 sub-boards for condition 1 of the "Cell/Charger Parametric Test Matrix", Table 1 attached. Verify that discharge and initial charge current levels are within tolerance.

B. Energize complete test system as follows:

1. Turn on bias supplies, fault scanner, fault power and timing pulse supply.

2. Verify that timing pulse occurs at 1-minute intervals on the 40-second mark of the DAS.

3. Remove all test racks from "power fault" condition using reset buttons on boards 5/6.

4. Turn on reset/synchronize/initial condition 24-volt power supply.

5. Turn on all main power. Verify that all racks show no lights.

6. Start DAS magnetic tape and printer. (Printer on continuous scan.) Start Bristol recorders. Verify that:

   a. Correct Julian date is on Manual Data Word thumbwheel display.

   b. Scan covers all desired channels.

   c. Bristol recorders are operating properly, and desired data is scanned.

7. Provide time marks on Bristol recorder chart paper correlating to DAS.

8. Between timing pulses, turn off reset-synchronize/initial condition supply. Verify that, on next pulse, all test stations enter discharge mode. Note start of test time on DAS printer, Bristol recorders and in log.

9. Change printer to 6-minute periodic scan after first four (4) scans in discharge mode.

10. After first orbit, change printer to 24-minute periodic scan.

C. Take the following hand data:

1. Open circuit cell voltages and cell pressures prior to start of test.

2. Cell pressures as follows: (PSIG only)

   a. 18 minutes into first discharge.

   b. End of first discharge.

   c. 29 minutes into first charge (65 minutes into first orbit).

   d. End of first charge.

   e. End of each discharge and each charge thereafter through the first day.

   f. On following days, end of a discharge and a charge in the morning, at noon, and at end of day, or at the discretion of the project engineer.

3. Flow rate data twice/day to verify that rate is within limits. Adjust as required, and note on data sheet.

D. For burn-in (test condition 1), at least 25 orbits shall be run ($\sim$39 hr, 10 min. duration). In any case, however, this condition shall be run until stability defined in F. below, is reached.

E. After 25 orbits or achievement of stability, whichever occurs last, proceed to test condition 2 after running capacity test (H. below), making the necessary changes in board 3 sub-boards, board 2 switches, load resistors, and flow rate. Run this condition for 13 orbits minimum ($\sim$ 20 hours, 22 min.) or to stability, whichever occurs last. Then set up and run conditions 3 through 12 in turn; each for 13 orbits minimum or to stability.

F. Stability shall be defined as achievement of <u>all</u> of the following criteria:

1. End-of-discharge <u>and</u> end-of-charge pressures shall not vary from orbit to orbit by more than 3 PSIG.

2. End-of-discharge and end-of-charge cell voltages (all cells in a string) shall not vary from orbit to orbit by more than 0.005 volts. (Note that end-of-charge voltage occurs during "trickle" charge ---- C/20.)

3. End-of-discharge and end-of-charge string outlet temperature and TSR temperature shall not vary from orbit-to-orbit by more than $2^{\circ}C$, provided that string inlet temperature variation is $\leq 1^{\circ}C$. If string inlet temperature variation is $> 1^{\circ}C$, string outlet temperature and TSR temperature variation shall be $\leq \Delta T$ inlet + $1^{\circ}C$. (<u>Note:</u> Flow rates must be stable.)

4. All of the above criteria shall hold for at least three (3) consecutive orbits.

G. Life cell test orbital conditions will be released after evaulation of parametric cell test data.

H. Within not more than two (2) hours after completion of test conditions 1, 6 and 12 respectively, repeat III. H through III. K, taking data as described therein. (<u>Note:</u> These are the capacity tests described in Table 1.)

CELL/CHARGER PARAMETRIC TEST MATRIX

				M1 - VOLT/TEMP LIMIT									M2 - PRESS. [illegible] LIMIT								
				L1			L2			L3			L1			L2			L3		
STRING NO	BURN IN *	TEMP	DESIGN	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
1	[illegible]	T1	P3	1	2		4	3		5		6	7		8	9	10		11	12	
2	1		P2	1	2		3		4		5	6	7	8		[illegible]		10		11	12
3	1		P1	1		2		4	3	6	5		7	8			9	10	11		12
4	1	T2	D1		1	2	4		3	5	6			7	8	9		10	11	12	
5	[illegible]		D2	1		2		4	3	5		6	7		8		9	10	11		12
6	1		D3	1	3		2		4		5	6	7	8		9		10		11	12
7	1	T3	D1	1	2		4	3		5		6	7		8	9	10		11	12	
8	[illegible]		P3			2	3	1	4	5	6			7	8	9		10	11	12	
9	1		P2	1		2		4	3	5	6		7	8			9	10	11		12

* ACHIEVEMENT OF ORBITAL PERFORMANCE STABILITY (ELECTRICAL, THERMAL, PRESSURE RANGE) AFTER A MINIMUM OF 25 ORBITS, COMPLETES BURN-IN AND TEST CONDITION D.

NOTES:

1. EACH TEST CONDITION SHALL BE RUN TO ORBITAL PERFORMANCE STABILITY OR A MINIMUM OF 13 ORBITS.
2. T1 = 0°C (32°F) INLET; T2 = 8°C (46°F) INLET; T3 = 18°C (64°F) INLET. ALL TEMPS ± 2.5°F.
3. L1 = 4.44V @ 20°C, 4.59V @ 0°C (FOR 3 CELLS) D1 = 12% DOD
   L2 = 4.53V @ 20°C, 4.68V @ 0°C D2 = 30% DOD
   L3 = 4.62V @ 20°C, 4.77V @ 0°C D3 = 50% DOD
4. CAPACITY TESTS SHALL BE RUN AS FOLLOWS (AT C/2 DISCH. RATE TO 0.90V FIRST CELL)
   a. AFTER INITIAL CONDITIONING
   b. AFTER BURN-IN STABILITY, THEN RUN TO STABILITY AGAIN
   c. AFTER TEST CONDITION (6)
   d. AFTER TEST CONDITION (12)

TABLE 4

AVOID VERBAL ORDERS

APPENDIX R-2

FROM M. Wertheim | 553/POD | 35 | 9142 | DATE 5/19/72

NAME | GROUP NO. & NAME | PLANT NO. | EXT.

NO. D559-2-22

TO: J. Gambale, Plt. 14, Battery Lab
V. Falcone, Plt. 14, Battery Lab

SUBJECT: FLOW RATES FOR PARAMETRIC AND LIFE TESTS

Reference: NAS-9-11074

Background

In order to achieve optimized outlet-inlet temperature differences, cells operating at different depths of discharge require different amounts of coolant per unit time. Present thermal estimates are for a temperature rise approximately 8°F, a reasonably usable figure, and are based on a per cell heat loss of:

DOD	Peak Dissipation - Watts/Cell
50%	12.0
30%	7.2
12%	3.0

The flow-rate tables in the following paragraphs are based on these figures

Flow Rate Tables

The following instructions apply to the flow rate tables:

1. To obtain flow rates for a string, multiply the appropriate figure in the table by the number of cells in the string. E.g.: To calculate flow rate for a 14-cell string in Bath 1 (32°F), at 12% DOD:

   Flow rate/cell = 43 cm^3/min.
   Flow rate/string = 43 x 14 = 602 cm^3/min.

2. All flow rate settings shall be accurate to within ±2%; and data shall be recorded.

TABLE OF FLOW RATES

DOD	Bath No.	Flow Rate -- CM^3/Min./Cell
50%	1	179
50%	2,3	183
30%	1	107
30%	2,3	110
12%	1	43
12%	2,3	44

SAC-377 REV. 4

Bath 1 -- 32°F, 17% ethylene clycol in water
Bath 2 -- 46°F, water only
Bath 3 -- 64°F, water only

NOTE: The above bath temperatures, taken with the appropriate flow rate for the selected DOD allow the average cell temperatures to be, respectively,

Bath 1 -- 36°F (2.2°C)
Bath 2 -- 50°F (10°C)
Bath 3 -- 68°F (20°C)

S. J. Gaston, Project Engineer

INFO cc:

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APPENDIX K-3

TURN-ON-PROCEDURES

I. All Operating Test Controllers

A. Turn on Master Control Panel, using momentary "on" switch.

1. Verify that all desired bias transformers are energized, and remain so when switch is released. (Pilot lights on panel).
2. Verify that Pulse Timing Power and Fault Power are energized, and remain so when switch is released. (PLS and FLT lights on panel).
3. Verify that bypass switch is in "Normal" position.

B. Verify that battery power leads to front of each test controller are open (S.U.T. position on panel of Board 7).

C. Energize bias to each controller in turn.

1. Place hanging toggle switch in "on" position. Verify presence of red light on front of Board 5/6.
2. Depress red pushbutton on side of Board 5/6. Verify that red light goes out and either discharge (amber) or charge (green) comes on.
3. Mode cycle rack as follows:
   a) If in discharge, depress top button on Board 4 (row of three). Charge light should come on. Then depress bottom button, discharge light should come on. Finally, again depress top button making charge light come on. Leave in charge.
   b) If in charge, depress bottom button making discharge light come on. Then, again depress top button causing charge light to come on. Leave in charge.
   c) Allow 20-30 seconds between each mode change.
4. With rack in charge mode from 3 above connect battery power leads to S.U.T. positions with proper polarity.
5. Verify that DAS paper tape is in "continuous" mode, and that mag. tape recorder is operating, and that Bristol recorders are operating. Allow <u>two</u> DAS scans to occur (these are open circuit).
   Verify that all cell reset channels are reading out, and that all storing current channels are zero. Verify that cell fault protection (over/under voltage detection) is on and scanning.
6. Again recheck all operating positions. Verify that all mode lights are green for charge. Turn on 24-V initial condition supply <u>between</u> 40-second marks. Verify that all rack mode lights are extinguished. After 5-10 seconds, and <u>before</u> the next 40-second mark, turn off the initial condition supply. At the upcoming 40-second mark, all racks should switch into discharge mode (amber lights). Allow DAS scan to occur. All current channels should show a low current reading.

I. <u>All Operating Test Controllers</u>(Cont'd.)

C. 6. Cont'd.

(The test showings will conduct through the load resistor and the shunt diode in the output of the of the Power Supply). <u>Note</u>: The 40 second marks are read on the digital clock of the DAS.

7. Turn on each Power supply in turn, verifying that all discharge currents are correct within allowable limits. After 2 DAS scans, return printer to normal.

B. The result of the above procedure will be that depths of discharge for orbit I of any text will be a bit short. This should have no significance on the test results. The procedure provides for safe, assured turn-On.

II. <u>Adding A Test Controller to Existing Run</u>

A. If the test showing was last discharged, do the following:

1. Verify that the test showing is disconnected from Board 7 of the rack.
2. Perform this procedure at the beginning of charge of the remaining racks.
3. Energize the rack per I.C. 1-5 above.
4. Connect test string to Board 7. Turn on Power Supply. Verify that initial current is ~83 Amps, and that the rack is capable of programming charge rate (use VOM on output of Board 2 detector).
5. Allow rack to reamin in charge until 50 seconds <u>before</u> scheduled transfer of rest of units to discharge. (Scheduled transfer occurs on 40-second mark as described above. The 50 seconds referred to, then, is at the 50 second mark before this point). At this point, depress the <u>center</u> button of the row of three on Board 4. The rack is now synchronized with the rest.

B. If the test string was last charged, do the following:

1. Repeat steps II 1-3 above, except in the last 5-10 minutes of charge.
2. During the last 2 minutes of charge, connect test string to Board 7, and turn on Power Supply. Verify that charge current goes to triply rate (or; at most ~20 Amps) immediately.
3. Repeat step II A 5 above.

MODT 49 PARAMETRIC TEST-DATE 158 STATISTICS FOR ORBIT NUMBER [illegible]

STRING NUMBER 1

DISCHARGE	C1	C2	C3	TIME	VOLT	TS4	SCV	AMP	[illegible]	[illegible]	TA2	[illegible]	[illegible]	[illegible]
START	1.365	1.364	0	34900.	58.545	58.318	2.728	25.918	0	0	0	0	0	0
END	1.235	1.235	0	42400.	59.455	59.591	2.470	25.910	0	0	0	0	0	0
CHARGE														
START I1	1.359	1.360	0	42500.	59.455	59.634	2.718	82.246	0	0	0	0	0	0
END I1	1.469	1.479	0	43000.	59.455	59.636	2.960	82.208	0	0	0	0	0	0
START I2	1.457	1.460	0	43100.	59.500	59.636	2.918	50.304	0	0	0	0	0	0
END I2	1.481	1.460	.000	43300.	59.455	59.682	2.961	50.248	0	0	0	0	0	0
START I3	1.449	1.445	.000	43400.	59.545	59.682	2.894	21.050	0	0	0	0	0	0
END I3	1.485	1.484		44100.	59.500	59.591	2.972	21.032	0	0	0	0	0	0
START I4	1.437	1.435	0	44200.	59.500	59.591	2.872	4.245	0	0	0	0	0	0
END I4	1.435	1.434		52200.	58.636	58.409	2.869	4.302	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
55.89	47.24	118.44

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
15.55	16.41	105.54

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
1	19.94	23.62	118.43
2	19.94	23.62	118.45

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
55.136	55.664	55.558

TOTAL HEAT IN WATT-HRS= 15581 AMBIENT CORRECTION= .7500 DEGREES F

APPENDIX R-4

PARAMETRIC CELL CHARACTERIZATION

COMPUTER PRINTOUTS OF STABILIZED CELL CHARACTERISTICS

FOR EACH STRING AT EACH TEST CONDITION

(MOD T 45 - MOD T 49)

MODY 45 PARAMETRIC TEST-DATE 152 STATISTICS FOR ORBIT NUMBER (20) 295

STRING NUMBER 2

DISCHARGE	C1	C2	C3	TIME	DLT	TSB	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.395	1.393	1.393	212900.	35.131	34.991	4.182	19.356	0	0	0	0	0	0
END	1.256	1.258	1.262	220400.	35.692	35.692	3.775	19.368	0	0	0	0	0	0
CHARGE														
START I1	1.376	1.385	1.383	220500.	35.738	35.738	4.144	81.944	0	0	0	0	0	0
END I1	1.506	1.521	1.522	220800.	35.785	35.785	4.549	82.236	0	0	0	0	0	0
START I2	1.479	1.491	1.490	220900.	35.785	35.789	4.460	49.832	0	0	0	0	0	0
END I2	1.479	1.491	1.490	220900.	35.785	35.795	4.460	49.832	0	0	0	0	0	0
START I3	1.477	1.486	1.493	221000.	35.835	35.879	4.456	20.590	0	0	0	0	0	0
END I3	1.542	1.523	1.531	221700.	35.879	35.925	4.596	20.598	0	0	0	0	0	0
START I4	1.498	1.467	1.472	221800.	35.835	35.879	4.419	4.074	0	0	0	0	0	0
END I4	1.455	1.451	1.451	230200.	35.224	34.991	4.357	4.134	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
45.44	51.27	112.82

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
11.62	11.74	101.02

WATT-HOURS OUT		WATT-HOURS IN.	PERCENT RETURN
4	15.13	17.05	112.72
5	15.15	17.11	112.95
6	15.17	17.11	112.80

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
34.336	34.991	34.640

TOTAL HEAT IN WATT-HRS= .90 AMBIENT CORRECTION= .7500 DEGREES F

R4-2

MODT AS PARAMETRIC TESTDATE 155 STATISTICS FOR ORBIT NUMBER (70) 344

STRING NUMBER 1

DISCHARGE	C1	C2	C3	TIME	OUT	TSR	SCV	AMP	A1	R1-MV	A2	R2-MV	A3	R3-MV
START	1.408	1.407	1.409	34900.	41.239	40.826	4.224	20.060	.5888	0	.4753	0	.3313	0
END	1.257	1.266	1.258	42400.	41.975	41.697	3.775	20.056	.5230	0	.4347	0	.2970	0
CHARGE														
START I1	1.382	1.377	1.374	42500.	41.972	41.743	4.133	82.334	.5979	0	.4863	0	.3321	0
END I1	1.5224	1.452	1.478	42700.	42.018	41.697	4.492	82.338	.6932	0	.5462	0	.3667	0
START I2	1.448	1.458	1.455	42800.	41.975	41.789	4.375	49.702	.6517	0	.5263	0	.3540	0
END I2	1.515	1.495	1.483	42900.	41.927	41.835	4.486	49.702	.6751	0	.5459	0	.3660	0
START I3	1.434	1.435	1.426	43000.	42.018	41.891	4.287	20.746	.6183	0	.5062	0	.3407	0
END I3	1.493	1.515	1.523	44100.	41.927	41.606	4.532	20.760	.6471	0	.5357	0	.3731	0
START I4	1.462	1.476	1.481	44200.	41.927	41.666	4.418	4.432	.6264	0	.5157	0	.3571	0
END I4	1.456	1.458	1.461	52200.	41.239	40.734	4.376	4.478	.6197	0	.4996	0	.3490	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
47.42	55.24	116.49

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
12.04	12.68	105.34

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
7	15.81	18.45	116.66
8	15.81	18.42	116.54
9	15.80	18.37	116.27

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
38.776	39.664	39.216

TOTAL HEAT IN WATT-HRS= 13.46 AMBIENT CORRECTION= .7500 DEGREES F

R4-3

MODT 46 PARAMETRIC TEST-DATE 155 STATISTICS FOR ORBIT NUMBER (70) 344

						STRING NUMBER		4						
DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.354	1.355	1.356	34900.	46.881	47.249	4.064	49.898	0	0	0	0	0	0
END	1.207	1.210	1.210	42400.	48.578	49.908	3.627	49.880	0	0	0	0	0	0
CHARGE														
START I1	1.333	1.331	1.329	42500.	48.624	49.908	3.993	82.546	0	0	0	0	0	0
END I1	1.497	1.493	1.492	43900.	48.211	49.266	4.482	82.558	0	0	0	0	0	0
START I2	1.459	1.458	1.457	44000.	48.211	49.266	4.374	50.984	0	0	0	0	0	0
END I2	1.486	1.484	1.483	44300.	48.165	49.174	4.453	50.992	0	0	0	0	0	0
START I3	1.444	1.444	1.443	44400.	48.119	49.128	4.331	20.954	0	0	0	0	0	0
END I3	1.482	1.497	1.493	45800.	47.569	48.211	4.473	20.972	0	0	0	0	0	0
START I4	1.437	1.441	1.441	45900.	47.569	48.211	4.319	4.660	0	0	0	0	0	0
END I4	1.431	1.433	1.432	52200.	46.927	47.294	4.296	4.674	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
113.49	136.18	119.99

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
29.93	31.58	105.53

	WATT-HOURS OUT	WATT-HOURS IN,	PERCENT RETURN
10	37.80	45.42	120.18
11	37.95	45.40	119.95
12	37.85	45.36	119.85

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
45.780	47.110	46.426

TOTAL HEAT IN WATT-HRS= 11.69 AMBIENT CORRECTION= .7500 DEGREES F

84-4

MODI 4A PARAMETRIC TEST-DATE 159 STATISTICS FOR ORBIT NUMBER 780/ 844

RING NUMBER 5

DISCHARGE		C1	C2	C3	TIME	OLT	TSO	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START		1.385	1.374	0	34900.	49.725	49.771	2.759	19.822	0	0	0	0	0	0
END		1.26[illegible]	1.242	0	42400.	50.40[illegible]	50.636	2.501	19.810	0	0	0	0	0	0
CHARGE															
START	I1	1.373	1.358	0	42500.	50.364	50.682	2.731	83.286	0	0	0	0	0	0
END	I1	1.477	1.448	0	42800.	50.364	50.636	2.918	83.286	0	0	0	0	0	0
START	I2	1.444	1.429	0	42900.	50.409	50.682	2.877	51.086	0	0	0	0	0	0
END	I2	1.469	1.447	0	43000.	50.455	50.622	2.916	51.092	0	0	0	0	0	0
START	I3	1.424	1.405	0	43100.	50.455	50.727	2.828	19.574	0	0	0	0	0	0
END	I3	1.44[illegible]	1.447	0	43800.	50.364	50.591	2.907	19.588	0	0	0	0	0	0
START	I4	1.443	1.435	0	43900.	50.318	50.5[illegible]	2.873	3.880	0	0	0	0	0	0
END	I4	1.434	1.426	0	52200.	49.817	49.771	2.860	3.932	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
[illegible].87	37.52	121.88

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
11.89	13.18	110.85

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
I3	15.54	18.92	121.79
I4	15.33	18.70	121.98

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
48.394	49.083	48.715

TOTAL HEAT IN WATT-HRS= 3.26 AMBIENT CORRECTION= .7800 DEGREES F

R 4-3

MODT 65 PARAMETRIC TEST-DATE 152 STATISTICS FOR ORBIT NUMBER (20) 295

STRING NUMBER 6

DISCHARGE		C1	C2	C3	TIME	VLT	TSB	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START		1.384	1.387	1.388	212900.	48.211	49.303	4.158	19.692	.3622	0	.3683	0	.5586	0
END		1.263	1.266	1.261	220400.	48.991	49.226	3.789	19.664	.3469	0	.3437	0	.5198	0
CHARGE															
START	I1	1.392	1.390	1.385	220500.	48.991	49.228	4.167	79.862	.3803	0	.3812	0	.5810	0
END	I1	1.466	1.463	1.459	220700.	48.991	49.174	4.391	79.872	.3995	0	.4176	0	.6161	0
START	I2	1.452	1.448	1.446	220800.	49.037	49.259	4.345	48.192	.3917	0	.4076	0	.6057	0
END	I2	1.488	1.482	1.476	221000.	48.991	49.266	4.446	48.200	.3993	0	.4199	0	.6210	0
START	I3	1.438	1.435	1.435	221100.	49.037	49.359	4.308	19.540	.3826	0	.3976	0	.5974	0
END	I3	1.493	1.481	1.489	221800.	48.991	49.266	4.463	19.563	.3938	0	.4136	0	.6191	0
START	I4	1.443	1.439	1.444	221900.	48.945	49.228	4.326	5.014	.3777	0	.3925	0	.5903	0
END	I4	1.458	1.455	1.465	230200.	48.257	48.257	4.378	5.024	.3853	0	.4005	0	.6043	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
66.16	56.93	123.33

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
11.79	13.10	111.17

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
16	15.37	19.01	123.68
17	15.42	18.96	122.96
18	15.36	18.95	123.36

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
47.110	47.936	47.499

TOTAL HEAT IN WATT-HRS= 3.58 AMBIENT CORRECTION= .7500 DEGREES F

R4-6

MODT 48 PARAMETRIC TEST-DATE 155 STATISTICS FOR ORBIT NUMBER [illegible] 144

STRING NUMBER

DISCHARGE	C1	C2	C3	TIME	OLF	ISR	SCV	AMP	A1	P1 MV	A2	P2 MV	A3	P3 MV
START	1.378	1.373	1.361	34900.	65.424	65.291	4.104	19.056	0	0	0	0	0	0
END	1.257	1.259	1.249	42400.	66.099	66.188	3.764	19.056	0	0	0	0	0	0
CHARGE														
START I1	1.379	1.376	1.378	42500.	66.188	66.188	4.133	84.292	0	0	0	0	0	0
END I1	1.407	1.403	1.407	42600.	66.143	66.188	4.214	81.286	0	0	0	0	0	0
START I2	1.429	1.424	1.430	42700.	66.143	66.188	4.283	48.270	0	0	0	0	0	0
END I2	1.429	1.424	1.430	43000.	66.099	66.188	4.283	48.280	0	0	0	0	0	0
START I3	1.395	1.394	1.394	43100.	66.143	66.188	4.182	19.123	0	0	0	0	0	0
END I3	1.433	1.434	1.432	44100.	65.964	65.964	4.301	19.134	0	0	0	0	0	0
START I4	1.409	1.411	1.405	44200.	65.919	65.919	4.225	4.280	0	0	0	0	0	0
END I4	1.418	1.425	1.412	52200.	65.426	65.335	4.254	4.318	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
44.61	54.14	121.36

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
11.43	12.81	112.01

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
19	14.90	18.05	121.19
20	14.91	18.05	121.06
21	14.80	18.04	121.85

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
64.664	65.247	64.939

TOTAL HEAT IN WATT-HRS= .59 AMBIENT CORRECTION= .7300 DEGREES F

R 4-

MODT 4E PARAMETRIC TEST-DATE 155 STATISTICS FOR ORBIT NUMBER (70) 344

STRING NUMBER 8

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.338	1.337	1.340	34900.	65.022	65.740	4.015	48.879	0	0	0	0	0	0
END	1.183	1.182	1.197	42400.	66.816	68.251	3.563	48.794	0	0	0	0	0	0
CHARGE														
START I1	1.332	1.330	1.328	42500.	66.906	68.296	3.990	83.844	0	0	0	0	0	0
END I1	1.488	1.404	1.467	43500.	66.547	67.873	4.439	83.878	0	0	0	0	0	0
START I2	1.459	1.455	1.442	43600.	66.547	67.752	4.356	50.110	0	0	0	0	0	0
END I2	1.492	1.486	1.475	44400.	66.323	67.339	4.453	50.132	0	0	0	0	0	0
START I3	1.448	1.444	1.435	44500.	66.323	67.220	4.327	19.666	0	0	0	0	0	0
END I3	1.472	1.473	1.510	51100.	65.471	65.964	4.455	19.756	0	0	0	0	0	0
START I4	1.437	1.436	1.451	51200.	65.471	65.964	4.323	4.848	0	0	0	0	0	0
END I4	1.416	1.417	1.421	52200.	65.381	65.785	4.254	4.880	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
110.08	138.95	126.22

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
29.29	32.19	109.89

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
22	36.61	46.44	126.84
23	36.61	46.36	126.62
24	36.86	46.15	125.22

THERMAL INFORMATION -- INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
64.305	65.291	64.820

TOTAL HEAT IN WATT-HRS# 8.66 AMBIENT CORRECTION= .7500 DEGREES F

44-8

MOOT 45 PARAMETRIC TEST-DATE 192 STATISTICS FOR ORBIT NUMBER (20) 112

STRING NUMBER 6

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	B1-MV	B2	B2-MV	B3	B3-MV
START	1.363	1.374	1.364	212900.	65.471	65.650	4.101	20.794	.4116	0	.6029	0	.7448	0
END	1.261	1.259	1.262	220400.	66.279	66.216	3.781	20.798	.3841	0	.5603	0	.6891	0
CHARGE														
START I1	1.392	1.372	1.389	220500.	66.369	66.891	4.152	82.678	.4352	0	.6200	0	.7770	0
END I1	1.435	1.419	1.431	220700.	66.278	66.861	4.286	91.372	.4480	0	.6513	0	.8094	0
START I2	1.415	1.415	1.412	220800.	66.325	66.816	4.232	49.356	.4392	0	.6441	0	.7958	0
END I2	1.444	1.431	1.440	221100.	66.323	66.771	4.315	49.358	.4453	0	.6545	0	.8112	0
START I3	1.406	1.420	1.404	221200.	66.278	66.771	4.211	19.748	.4310	0	.6360	0	.7647	0
END I3	1.43[illegible]	1.43[illegible]	1.427	222100.	66.145	66.457	4.296	19.762	.4352	0	.6481	0	.7941	0
START I4	1.417	1.429	1.414	222200.	66.096	66.413	4.260	4.844	.4327	0	.6476	0	.7895	0
END I4	1.412	1.447	1.412	230200.	65.516	65.748	4.271	4.880	.4328	0	.6493	0	.7814	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
48.77	61.32	125.73

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
12.48	14.43	115.65

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
25	16.26	20.47	125.86
26	16.23	20.42	125.81
27	16.28	20.43	125.52

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
64.395	64.978	64.717

TOTAL HEAT IN WATT-HRS= 3.57 AMBIENT CORRECTION= .7500 DEGREES F

MOST 4A PARAMETRIC TEST-DATE 159 STATISTICS FOR ORBIT NUMBER 392

STRING NUMBER 1

DISCHARGE	C1	C2	C3	TIME	ALT	TSR	SCV	AMP	A1	P1-HV	A2	P2-HV	A3	P3-HV
START	1.321	1.322	0	65100.	34.757	35.879	2.643	56.696	0	0	0	0	0	0
END	1.159	1.158	0	72600.	36.539	38.963	2.317	56.650	0	0	0	0	0	0
CHARGE														
START I1	1.325	1.327	0	72700.	36.539	39.029	2.652	81.818	0	0	0	0	0	0
END I1	1.514	1.519	0	74100.	36.539	38.449	3.035	81.856	0	0	0	0	0	0
START I2	1.529	1.533	0	74200.	36.346	38.495	3.062	49.964	0	0	0	0	0	0
END I2	1.522	1.525	0	74800.	36.252	38.355	3.047	49.980	0	0	0	0	0	0
START I3	1.48	1.482	0	74900.	36.252	38.308	2.962	20.830	0	0	0	0	0	0
END I3	1.528	1.534	0	80700.	35.598	37.047	3.062	20.852	0	0	0	0	0	0
START I4	1.449	1.451	0	80800.	35.551	36.953	2.899	4.366	0	0	0	0	0	0
END I4	1.432	1.432	0	82400.	34.991	36.019	2.864	4.392	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
83.01	98.79	119.02

AMP-HOURS OUT	AMP-HOURS IN ,	PERCENT RETURN
33.99	33.82	99.49

WATT-HOURS OUT		WATT-HOURS IN.	PERCENT RETURN
1	41.51	49.36	118.91
2	41.50	49.44	119.13

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
33.542	34.834	34.256

TOTAL HEAT IN WATT-HRS= 7.12 AMBIENT CORRECTION= 1.0000 DEGREES F

R4-10

MODE 4A PARAMETRIC TEST-DATE 199 STATISTICS FOR ORBIT NUMBER 392

SERIAL NUMBER

ALARM CONDITION EXISTS

DISCHARGE	C1	C2	C3	TIME	OLT	TSP	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.399	1.397	1.397	65100.	40.415	40.046	4.193	19.326	0	0	0	0	0	0
END	1.261	1.264	1.258	72600.	41.101	40.826	3.792	19.336	0	0	0	0	0	0
CHARGE														
START I1	1.377	1.387	1.385	72700.	41.147	40.872	4.150	82.040	0	0	0	0	0	0
END I1	1.523	1.521	1.521	73000.	41.193	40.972	4.546	82.210	0	0	0	0	0	0
START I2	1.497	1.490	1.489	73100.	41.193	40.917	4.459	49.810	0	0		0	0	0
END I2	1.430	1.490	1.489	73100.	41.193	40.917	4.459	49.810	0	0	0	0	0	0
START I3	1.527	1.541	1.545	73200.	41.193	40.963	4.613	20.584	0	0	0	0	0	0
END I3	1.543	1.523	1.531	74000.	41.284	41.055	4.597	20.520	0	0	0	0	0	0
START I4	1.445	1.444	1.444	74100.	41.284	41.055	4.334	4.100	0	0	0	0	0	0
END I4	1.453	1.449	1.449	82400.	40.689	40.321	4.351	4.128	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
45.62	52.70	115.52

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
11.60	12.02	103.59

WATT-HOURS OUT		WATT-HOURS IN.	PERCENT RETURN
4	15.20	17.58	115.66
5	15.20	17.58	115.64
6	15.23	17.59	115.45

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
38.916	39.850	39.440

TOTAL HEAT IN WATT-HRS= 3.94 AMBIENT CORRECTION= 1.0000 DEGREES F

R4-1

MODT A4 PARAMETRIC TEST-DATE 139 STATISTICS FOR ORBIT NUMBER 398

STRING NUMBER 3

DISCHARGE	C1	C2	C3	TIME	OLT	TSB	SCV	AMP	A1	A1-MV	A2	A2-MV	A3	A3-MV
START	1.350	1.346	1.348	69100.	32.748	32.935	4.045	82.282	.5181	0	.3991	0	.2961	0
END	1.154	1.155	1.154	72600.	35.645	37.748	3.457	82.406	.4692	0	.3796	0	.2987	0
CHARGE														
START I1	1.384	1.385	1.385	72700.	35.733	37.794	3.915	82.399	.5817	0	.4414	0	.3362	0
END I1	1.534	1.527	1.524	75300.	34.456	35.037	4.595	82.372	.6480	0	.5009	0	.3555	0
START I2	1.485	1.491	1.492	75400.	34.103	35.034	4.455	49.784	.6141	0	.4758	0	.3371	0
END I2	1.533	1.535	1.523	80000.	33.916	34.874	4.592	49.792	.6401	0	.4945	0	.3536	0
START I3	1.459	1.465	1.457	80100.	33.869	34.715	4.382	20.662	.5880	0	.4564	0	.3252	0
END I3	1.523	1.532	1.536	82100.	32.935	33.168	4.591	20.690	.6270	0	.4869	0	.3606	0
START I4	1.471	1.474	1.474	82200.	32.935	33.121	4.418	5.598	.5903	0	.4552	0	.3329	0
END I4	1.459	1.459	1.459	82400.	32.841	33.027	4.378	5.620	.5833	0	.4482	0	.3259	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
180.76	218.47	120.87

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
49.37	50.19	101.66

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
7	60.29	72.78	120.71
8	60.16	73.01	121.35
9	60.30	72.69	120.54

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
31.346	33.121	32.225

TOTAL HEAT IN WATT-HRS= 30.42 AMBIENT CORRECTION= 1.0001 DEGREES F

R4-12

HODT 46 PARAMETRIC TEST-DATE 159 STATISTICS FOR ORBIT NUMBER 358

DISCHARGE	C1	C2	C3	TIME	DCT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.318	1.320	1.322	13500.	45.688	46.1[illegible]	3.961	84.456	0	0	0	0	0	0
END	1.155	1.158	1.162	21000.	44.946	51.4[illegible]	3.475	84.460	0	0	0	0	0	0
CHARGE														
START I1	1.306	1.306	1.3[illegible]	21100.	44.991	51.500	3.917	82.616	0	0	0	0	0	0
END I1	1.496	1.493	1.600	23800.	46.972	49.119	4.473	82.612	0	0	0	0	0	0
START I2	1.461	1.462	1.456	23900.	46.927	48.028	4.378	51.962	0	0	0	0	0	0
END I2	1.494	1.494	1.468	24600.	46.597	47.651	4.475	51.968	0	0	0	0	0	0
START I3	1.443	1.446	1.44[illegible]	24700.	46.605	47.613	4.329	21.000	1	0	0	0	0	0
END I3	1.486	1.516	1.494	30300.	45.875	46.375	4.435	21.012	0	0	0	0	0	0
START I4	1.429	1.433	1.432	30400.	45.875	46.376	4.294	4.642	0	0	0	0	0	0
END I4	1.422	1.425	1.424	30800.	45.734	46.147	4.271	4.656	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
185.52	223.99	120.75

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
56.68	52.12	102.85

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
10	61.72	74.74	121.09
11	61.83	74.76	120.91
12	61.94	74.49	120.25

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
44.679	46.881	45.771

TOTAL HEAT IN WATT-HRS= 13.28 AMBIENT CORRECTION= 1.0000 DEGREES F

24-1

MODT 4A PARAMETRIC TEST-DATE 159 STATISTICS FOR ORBIT NUMBER 390

					STRING NUMBER			5						
DISCHARGE	C1	C2	C3	TIME	OUT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.312	1.308	0	130300.	46.429	47.248	2.619	81.118	0	0	0	0	0	0
END	1.174	1.162	0	133800.	49.312	52.091	2.336	81.104	0	0	0	0	0	0
CHARGE														
START I1	1.319	1.313	.005	133900.	49.494	52.136	2.633	83.192	0	0	0	0	0	0
END I1	1.471	1.473	0	140200.	48.028	49.862	2.943	83.176	0	0	0	0	0	0
START I2	1.457	1.451	0	140300.	48.028	49.765	2.901	51.023	0	0	0	0	0	0
END I2	1.469	1.471	0	141300.	47.559	48.945	2.940	51.046	0	0	0	0	0	0
START I3	1.432	1.432		141400.	47.477	48.945	2.865	19.524	0	0	0	0	0	0
END I3	1.462	1.466		142900.	46.789	47.706	2.928	19.549	0	0	0	0	0	0
START I4	1.429	1.430	0	143000.	46.697	47.601	2.859	3.852	0	0	0	0	0	0
END I4	1.414	1.415	0	143600.	46.516	47.231	2.829	3.864	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
118.22	139.35	117.87

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
48.62	48.74	100.25

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
13	59.26	69.68	117.58
14	58.96	69.66	118.16

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
44.771	46.468	45.577

TOTAL HEAT IN WATT-HRS= 27.62 AMBIENT CORRECTION= 1.0000 DEGREES F

R4-19

NODI 44 PARAMETRIC TEST-DATE 159 STATISTICS FOR ORBIT NUMBER 392

DISCHARGE	C1	C2	C3	TIME	OUT	[illegible]	[illegible]	[illegible]	A1	[illegible]	A2	[illegible]	A3	[illegible]
START	1.387	1.369	1.390	65100.	48.578	48.394	4.166	19.656	.3644	0	.3799	0	.5808	0
END	1.261	1.264	1.258	72600.	49.312	49.266	3.782	19.650	.3449	0	.3531	0	.5395	0
CHARGE														
START I1	1.399	1.389	1.384	72700.	49.312	49.312	4.162	19.866	.3841	0	.4043	0	.6035	0
END I1	1.472	1.406	1.401	72900.	49.312	49.358	4.399	19.862	.4094	0	.4345	0	.6415	0
START I2	1.455	1.449	1.448	73000.	49.458	49.358	4.352	48.195	.4002	0	.4236	0	.6319	0
END I2	1.492	1.484	1.479	73200.	49.414	49.450	4.454	48.194	.4093	0	.4367	0	.6450	0
START I3	1.443	1.439	1.438	73300.	49.404	49.450	4.323	19.520	.3899	0	.4130	0	.6222	0
END I3	1.497	1.485	1.491	74000.	49.266	49.312	4.473	19.546	.4026	0	.4295	0	.6428	0
START I4	1.441	1.437	1.439	74100.	49.312	49.312	4.317	5.008	.3812	0	.4041	0	.6106	0
END I4	1.458	1.453	1.469	82400.	48.578	48.532	4.380	5.030	.3877	0	.4109	0	.6241	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
46.19	57.02	123.46

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
11.79	13.16	111.17

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
16	15.39	19.15	123.82
17	15.44	18.99	123.01
18	15.36	18.98	123.55

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
47.395	48.211	47.779

TOTAL HEAT IN KILOJOULES = 1.70 AMBIENT CORRECTION= 1.0000 DEGREES F

MODT 4A PARAMETRIC TEST-DATE 159 STATISTICS FOR ORBIT NUMBER 392

STRING NUMBER 7

DISCHARGE	C1	C2	C3	TIME	VOLT	TSR	SCV	AMP	P1	P1-AV	P2	P2-AV	P3	P3-AV
START	1.336	1.334	1.327	65100.	64.490	64.350	3.999	48.364	0	0	0	0	0	0
END	1.191	1.191	1.171	72600.	66.278	66.637	3.553	48.352	0	0	0	0	0	0
CHARGE														
START I1	1.315	1.315	1.316	72700.	66.323	66.[illegible]	3.995	81.062	0	0	0	0	0	0
END I1	1.41[illegible]	1.416	1.431	73600.	66.[illegible]94	66.278	4.265	81.046	0	0	0	0	0	0
START I2	1.41[illegible]	1.399	1.412	73700.	66.099	66.239	4.212	48.138	0	0	0	0	0	0
END I2	1.43	1.43[illegible]	1.441	74500.	65.740	65.740	4.301	48.164	0	0	0	0	0	0
START I3	1.397	1.398	1.436	74600.	65.695	65.695	4.201	18.902	0	0	0	0	0	0
END I3	1.433	1.436	1.435	81000.	64.798	64.619	4.304	18.900	0	0	0	0	0	0
START I4	1.4[illegible]6	1.4[illegible]9	1.477	81100.	64.753	64.619	4.222	4.096	0	0	0	0	0	0
END I4	1.462	1.404	1.400	82400.	64.574	64.395	4.205	4.078	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
1[illegible].76	125.90	115.76

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
29.[illegible]1	29.99	1[illegible].35

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
19	[illegible]5.36	41.88	115.17
20	[illegible]4.39	41.89	115.11
21	[illegible]9.61	42.14	117.62

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
63.812	65.426	64.586

TOTAL HEAT IN WATT-HRS= -4.4[illegible] AMBIENT CORRECTION= 1.0000 DEGREES F.

R4-16

MODT 46 PARAMETRIC TEST-DATE 189 STATISTICS FOR ORBIT NUMBER 350

DISCHARGE	C1	C2	C3	TIME	OUT	TSR	SCV	AMP	A1	P1-V	A2	P2-V	A3	P3-V
START	1.294	1.297	1.302	130300.	63.632	63.812	3.893	83.224	0	0	0	0	0	0
END	1.266	1.267	1.270	133800.	64.843	65.656	3.803	-0.492	0	0	0	0	0	0
CHARGE														
START I1	1.356	1.356	1.350	133900.	64.751	65.516	4.062	83.772	0	0	0	0	0	0
END I1	1.495	1.487	1.475	134800.	64.350	65.112	4.458	83.750	0	0	0	0	0	0
START I2	1.462	1.458	1.446	134900.	64.350	65.192	4.366	49.878	0	0	0	0	0	0
END I2	1.469	1.464	1.473	135400.	64.305	65.022	4.446	49.878	0	0	0	0	0	0
START I3	1.451	1.446	1.437	135500.	64.357	64.978	4.333	19.820	0	0	0	0	0	0
END I3	1.478	1.479	1.505	141500.	63.946	64.260	4.461	19.900	0	0	0	0	0	0
START I4	1.429	1.429	1.431	141600.	63.901	64.345	4.289	4.930	0	0	0	0	0	0
END I4	1.417	1.419	1.422	143600.	63.722	63.961	4.258	4.994	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
90.28	118.37	131.11

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
24.65	27.36	111.00

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
22	30.00	39.56	131.88
23	30.02	39.49	131.55
24	30.27	39.32	129.91

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
63.408	64.464	63.876

TOTAL HEAT IN WATT-HRS= -17.53 AMBIENT CORRECTION= 1.0000 DEGREES F

R 4-

MODT A6 PARAMETRIC TEST-DATE 199 STATISTICS FOR ORBIT NUMBER 392

						STRING NUMBER	9								
DISCHARGE	C1	C2	C3	TIME	CLT	TSR	SCV	AMP	A1	A1-MV	A2	A2-MV	A3	A3-MV
START	1.365	1.375	1.360	65100.	64.976	65.292	4.106	20.788	.3984	0	.6132	0	.7386	0
END	1.257	1.258	1.259	72600.	65.746	66.233	3.775	20.776	.3652	0	.5720	0	.6772	0
CHARGE														
START I1	1.394	1.373	1.392	72783.	65.835	66.323	4.159	82.492	.6203	0	.6346	0	.7696	0
END I1	1.439	1.423	1.436	72599.	65.765	66.233	4.298	82.482	.6351	0	.6871	0	.8031	0
START I2	1.416	1.406	1.414	73000.	65.836	66.278	4.235	49.362	.4254	0	.6576	0	.7070	0
END I2	1.446	1.432	1.443	73300.	65.765	66.233	4.322	49.346	.6325	0	.6671	0	.8041	0
START I3	1.487	1.401	1.405	73400.	65.746	66.233	4.212	19.730	.4171	0	.6476	0	.7757	0
END I3	1.435	1.443	1.431	74400.	65.561	65.830	4.310	19.756	.4224	0	.6600	0	.7866	0
START I4	1.407	1.418	1.405	74500.	65.516	65.822	4.222	4.846	.4105	0	.6372	0	.7667	0
END I4	1.415	1.447	1.413	82400.	65.025	65.202	4.275	4.866	.4184	0	.6586	0	.7726	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
43.75	62.66	120.54

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
12.47	14.72	118.30

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
25	16.25	20.92	128.76
26	16.23	20.85	128.49
27	16.27	20.89	128.38

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
64.126	64.779	64.383

TOTAL HEAT IN WATT-HRS= -0.76 AMBIENT CORRECTION= 1.0000 DEGREES F

STRING NUMBER 2 RESTORED TIME= 82900 ORBIT= 393

STRING NUMBER 8 RESTORED TIME= 82900 ORBIT= 393

************************ALARM *************************

STRING 5 SHUTDOWN TIME= 85700

STRING NUMBER 5 RESTORED TIME= 85900 ORBIT= 393

R4-18

MODE 4? PARAMETRIC [illegible] TEST-RATE 1&2 STATISTICS FOR ORBIT NUMBER [illegible]

STRING NUMBER 1

DISCHARGE		C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START		1.328	1.326	0	85800.	34.666	35.879	2.652	56.664	0	0	0	0	0	0
END		1.160	1.160	0	93300.	36.159	38.729	2.319	56.624	0	0	0	0	0	0
CHARGE															
START	I1	1.323	1.329	0	93400.	36.206	38.776	2.656	81.840	0	0	0	0	0	0
END	I1	1.549	1.546	0	94900.	35.839	38.215	3.095	81.732	0	0	0	0	0	0
START	I2	1.514	1.515	0	95000.	35.785	38.262	3.029	49.936	0	0	0	0	0	0
END	I2	1.549	1.557	0	95500.	35.839	38.121	3.099	49.954	0	0	0	0	0	0
START	I3	1.439	1.500	0	95600.	35.832	38.075	2.999	20.904	0	0	0	0	0	0
END	I3	1.547	1.554	0	101300.	35.178	36.860	3.101	20.832	0	0	0	0	0	0
START	I4	1.50[illegible]	1.5[illegible]6	0	101400.	35.179	36.860	3.006	4.335	0	0	0	0	0	0
END	I4	1.429	1.439	0	103100.	34.477	35.692	2.578	4.374	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
93.03	100.66	121.22

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
33.98	34.16	100.52

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
1	41.51	50.31	121.20
2	41.52	50.35	121.25

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
33.262	34.43?	33.879

TOTAL HEAT IN WATT-HRS= -26.54 AMBIENT CORRECTION= 3.5000 DEGREES F

R4-

MODT 47 PARAMETRIC TEST-DATE 163 STATISTICS FOR UNIT NUMBER 437

STATAG NUMBER 2

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.415	1.410	1.412	85800.	43.991	43.578	4.237	19.344	0	0	0	0	0	0
END	1.271	1.277	1.278	93300.	44.728	44.404	3.929	19.362	0	0	0	0	0	0
CHARGE														
START I1	1.385	1.395	1.393	93400.	44.771	44.4 4	4.173	82.004	0	0	0	0	0	0
END I1	1.495	1.5 7	1.508	93700.	44.817	44.456	4.510	82.188	0	0	0	0	0	0
START I2	1.549	1.561	1.573	93800.	44.771	44.495	4.704	49.792	0	0	0	0	0	0
END I2	1.52[illegible]	1.538	1.537	93900.	44.817	44.641	4.595	49.800	0	0	0	0	0	0
START I3	1.469	1.476	1.474	94000.	44.862	44.641	4.420	20.592	0	0	0	0	0	0
END I3	1.566	1.544	1.555	94500.	44.908	44.587	4.665	20.614	0	0	0	0	0	0
START I4	1.472	1.456	1.467	94600.	44.908	44.633	4.465	4.112	0	0	0	0	0	0
END I4	1.466	1.459	1.460	103100.	44.174	43.624	4.384	4.150	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
45.94	53.11	115.61

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
11.61	12.01	103.46

WATT-HOURS OUT		WATT-HOURS IN.	PERCENT RETURN
4	15.30	17.65	115.36
5	15.31	17.74	115.86
6	15.33	17.73	115.60

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER.
41.835	42.569	42.177

TOTAL HEAT IN WATT-HRS=-264.86 AMBIENT CORRECTION= 35.0000 DEGREES F

R4-20

MODT 47 PARAMETRIC TEST-DATE 163 STATISTICS FOR CELL NUMBER 441

STRING NUMBER 3

DISCHARGE	C1	C2	C3	TIME	CL1	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.361	1.356	1.358	85500.	32.308	33.495	4.076	82.112	.5724	0	.4430	0	.3526	0
END	1.149	1.15[illegible]	1.146	93300.	35.206	38.355	3.445	82.354	.5160	0	.4210	0	.3359	0
CHARGE														
START I1	1.386	1.3[illegible]7	1.3[illegible]7	93400.	36.252	38.4[illegible]2	3.919	82.374	.5024	0	.4820	0	.3760	0
END I1	1.551	1.547	1.542	100000.	34.523	35.551	4.641	82.400	.7040	0	.5408	0	.4024	0
START I2	1.5[illegible]	1.514	1.5[illegible]1	100100.	34.477	35.551	4.509	49.800	.6698	0	.5171	0	.3853	0
END I2	1.563	1.557	1.553	100700.	34.298	35.271	4.673	49.818	.7040	0	.5407	0	.4049	0
START I3	1.481	1.4[illegible]1	1.480	100800.	34.298	35.224	4.441	20.684	.6444	0	.4987	0	.3748	0
END I3	1.547	1.553	1.573	102800.	33.308	33.542	4.673	20.712	.6920	0	.5378	0	.4221	0
START I4	1.490	1.49[illegible]	1.497	102900.	33.215	33.495	4.477	5.638	.6497	0	.5009	0	.3892	0
END I4	1.477	1.473	1.478	103100.	33.121	33.4[illegible]2	4.426	5.642	.6415	0	.4929	0	.3840	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
180.45	220.20	182.02

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
49.34	50.20	101.75

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
7	[illegible].20	73.39	121.91
8	60.19	73.40	121.96
9	[illegible]	73.40	122.20

THERMAL INFORMATION - INLET TEMPERATURE IN DEG.F

LOW	HIGH	AVER
31.626	33.495	32.494

TOTAL HEAT IN WATT-HRS=1112.3* AMBIENT CORRECTION= 35.0000 DEGREES F

MODI 47 PARAMETRIC TEST-DATE 163 STATISTICS FOR ORBIT NUMBER 411

STRING NUMBER 4

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.329	1.330	1.332	85800.	45.872	46.274	3.991	84.456	0	0	0	0	0	0
END	1.174	1.172	1.174	93300.	49.037	51.500	3.516	84.490	0	0	0	0	0	0
CHARGE														
START I1	1.316	1.315	1.314	93400.	49.174	51.591	3.945	82.606	0	0	0	0	0	0
END I1	1.489	1.459	1.487	100100.	47.018	48.211	4.465	82.634	0	0	0	0	0	0
START I2	1.459	1.460	1.458	100200.	46.927	48.165	4.376	50.968	0	0	0	0	0	0
END I2	1.489	1.490	1.482	100900.	46.651	47.798	4.465	50.974	0	0	0	0	0	0
START I3	1.444	1.447	1.442	101000.	46.606	47.641	4.333	21.010	0	0	0	0	0	0
END I3	1.484	1.497	1.489	102700.	45.826	46.376	4.469	21.032	0	0	0	0	0	0
START I4	1.488	1.502	1.493	102900.	45.786	46.330	4.483	4.654	0	0	0	0	0	0
END I4	1.435	1.437	1.436	103100.	45.734	46.284	4.307	4.676	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN,	PERCENT RETURN
186.99	225.49	120.59

AMP-HOURS OUT	AMP-HOURS IN ,	PERCENT RETURN
50.69	52.41	103.40

	WATT-HOURS OUT	WATT-HOURS IN,	PERCENT RETURN
10	62.23	75.19	120.82
11	62.35	75.21	120.62
12	62.41	75.19	120.32

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
44.908	47.110	45.925

TOTAL HEAT IN WATT-HRS=1133.98 AMBIENT CORRECTION= 35.0000 DEGREES F

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MODT W7 PARAMETRIC TEST-DATE 183 STATISTICS FOR ORBIT NUMBER 38V

STRING NUMBER 5

DISCHARGE	C1	C2	C3	TIME	CLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.333	1.327	0	141000.	48.514	47.248	2.659	81.002	0	0	0	0	0	0
END	1.177	1.160	0	144500.	49.541	52.636	2.338	81.072	0	0	0	0	0	0
CHARGE														
START I1	1.334	1.326	0	144600.	49.633	52.682	2.660	83.186	0	0	0	0	0	0
END I1	1.515	1.518	0	151100.	48.165	49.771	3.034	83.172	0	0	0	0	0	0
START I2	1.483	1.485	0	151200.	48.119	49.725	2.968	51.022	0	0	0	0	0	0
END I2	[illegible]	1.505	0	151900.	47.844	49.358	3.014	51.042	0	0	0	0	0	0
START I3	1.473	1.469	0	152000.	47.799	49.174	2.942	19.506	0	0	0	0	0	0
END I3	1.482	1.464	0	153800.	46.935	47.601	2.947	19.540	0	0	0	0	0	0
START I4	1.438	1.429	0	153900.	46.835	47.515	2.858	3.850	0	0	0	0	0	0
END I4	1.423	1.418	0	154300.	46.696	47.385	2.841	3.870	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
119.42	143.28	119.98

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
48.56	49.27	101.47

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
13	59.92	71.70	119.66
14	59.50	71.58	120.30

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
44.954	46.927	45.897

TOTAL HEAT IN WATT-HRS= -30.90 AMBIENT CORRECTION= 3.5000 DEGREES F

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MODT #7 PARAMETRIC - TEST-DATE 163 STATISTICS FOR ORBIT NUMBER 411

STRING NUMBER 4

DISCHARGE	C1	C2	C3	TIME	CLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.393	1.396	1.397	88900.	49.404	49.174	4.186	19.638	.4066	0	.4098	0	.6371	0
END	1.267	1.271	1.264	93300.	50.800	49.817	3.802	19.638	.3876	0	.3843	0	.5920	0
CHARGE														
START I1	1.395	1.393	1.388	93400.	50.045	49.862	4.176	79.866	.4280	0	.4343	0	.6587	0
END I1	1.577	1.498	1.493	93700.	50.045	49.939	4.498	79.852	.4609	0	.4731	0	.7106	0
START I2	1.484	1.477	1.475	93800.	49.954	49.862	4.435	48.178	.4484	0	.4596	0	.6981	0
END I2	1.531	1.520	1.519	94000.	49.908	49.862	4.561	48.198	.4619	0	.4768	0	.7136	0
START I3	1.464	1.459	1.459	94100.	50.000	49.862	4.382	19.522	.4346	0	.4455	0	.6833	0
END I3	1.531	1.525	1.526	94700.	50.000	49.862	4.578	19.540	.4558	0	.4712	0	.7151	0
START I4	1.455	1.451	1.451	94900.	49.954	49.862	4.356	5.002	.4244	0	.4346	0	.6699	0
END I4	1.479	1.469	1.493	103100.	49.037	48.761	4.429	5.036	.4350	0	.4447	0	.6927	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
46.31	58.60	126.53

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
11.78	13.32	113.09

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
16	15.43	19.58	126.94
17	15.48	19.51	126.04
18	15.40	19.51	126.62

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
47.248	48.257	47.817

TOTAL HEAT IN WATT-HRS= -13.48 AMBIENT CORRECTION= 3.5000 DEGREES F

R4-24

MODT 47 PARAMETRIC TEST-DATE 163 STATISTICS FOR ORBIT NUMBER 431

STRING NUMBER 7

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.344	1.344	1.332	85800.	65.255	65.425	4.520	48.384	0	0	0	0	0	0
END	1.203	1.204	1.188	93300.	67.346	67.623	3.595	48.352	0	0	0	0	0	0
CHARGE														
START I1	1.327	1.325	1.328	93400.	67.385	67.633	3.983	81.062	0	0	0	0	0	0
END I1	1.457	1.454	1.471	94600.	66.682	67.040	4.392	81.045	0	0	0	0	0	0
START I2	1.431	1.429	1.445	94700.	66.637	66.936	4.305	48.146	0	0	0	0	0	0
END I2	1.453	1.461	1.474	95400.	66.368	66.592	4.399	48.160	0	0	0	0	0	0
START I3	1.427	1.426	1.436	95500.	66.368	66.592	4.289	18.894	0	0	0	0	0	0
END I3	1.447	1.476	1.473	101300.	65.656	65.746	4.416	18.908	0	0	0	0	0	0
START I4	1.422	1.424	1.438	101400.	65.657	65.656	4.219	4.059	0	0	0	0	0	0
END I4	1.417	1.429	1.413	103100.	65.247	55.247	4.250	4.066	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
109.50	135.08	123.36

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
28.81	31.41	108.97

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
19	36.59	44.95	122.84
20	36.64	44.91	122.60
21	36.28	45.22	124.66

THERMAL INFORMATION - INLET TEMPERATURE IN DEG.F.

LOW	HIGH	AVER.
64.215	65.695	65.032

TOTAL HEAT IN WATT-HRS= -49.68 AMBIENT CORRECTION= 3.5000 DEGREES F

MODT 47 PARAMETRIC TEST-DATE 143 STATISTICS FOR ORBIT NUMBER 611

					STRING NUMBER			8						
DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.296	1.295	1.303	85800.	63.498	63.587	3.894	83.392	0	0	0	0	0	0
END	1.245	1.245	1.251	93300.	65.567	60.726	3.741	.002	0	0	0	0	0	0
CHARGE														
START I1	1.331	1.334	1.337	93400.	65.471	66.593	3.995	83.632	0	0	0	0	0	0
END I1	1.525	1.517	1.497	94900.	64.709	65.635	4.539	83.682	0	0	0	0	0	0
START I2	1.495	1.487	1.469	95000.	64.753	65.695	4.451	49.808	0	0	0	0	0	0
END I2	1.526	1.516	1.504	95700.	64.819	65.516	4.546	49.844	0	0	0	0	0	0
START I3	1.472	1.465	1.454	95800.	66.529	65.426	4.391	19.786	0	0	0	0	0	0
END I3	1.569	1.568	1.569	101600.	64.178	64.709	4.566	19.856	0	0	0	0	0	0
START I4	1.443	1.444	1.449	101700.	64.268	64.779	4.336	4.874	0	0	0	0	0	0
END I4	1.42	1.422	1.429	103100.	63.991	64.305	4.271	4.934	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
118.72	158.12	133.18

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
32.97	36.25	109.95

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
22	39.44	52.88	134.10
23	39.42	52.76	133.84
24	39.86	52.47	131.63

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
63.408	64.798	64.094

TOTAL HEAT IN WATT-HRS= -96.95 AMBIENT CORRECTION= 3.5000 DEGREES F

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NODT 47 PARAMETRIC TEST-DATE H63 STATISTICS FOR ORBIT NUMBER 1431

STRING NUMBER 9

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.305	1.304	1.308	85800.	63.543	63.632	3.917	88.086	.3329	0	.5276	0	.6368	0
END	1.144	1.161	1.157	93300.	67.265	69.656	3.462	82.400	.3000	0	.5047	0	.5805	0
CHARGE														
START I1	1.3[illegible]	1.311	1.30[illegible]	93400.	67.354	69.776	3.928	92.382	.3595	0	.5791	0	.6732	0
END I1	1.482	1.474	1.471	100000.	65.516	66.726	4.430	92.076	.3915	0	.6411	0	.7618	0
START I2	1.452	1.456	1.445	100100.	65.473	66.642	4.347	49.254	.3817	0	.6257	0	.7446	0
END I2	1.476	1.475	1.468	100900.	65.067	66.054	4.419	49.282	.3949	0	.6361	0	.7569	0
START I3	1.436	1.436	1.431	101000.	65.067	66.054	4.304	19.652	.3814	0	.6134	0	.7317	0
END I3	1.452	1.499	1.447	102700.	54.358	64.043	4.398	19.680	.4037	0	.6596	0	.7519	0
START I4	1.419	1.426	1.414	102800.	54.357	64.798	4.269	4.718	.3935	0	.6186	0	.7286	0
END I4	1.411	1.424	1.409	103100.	54.268	64.7[illegible]	4.243	4.748	.3911	0	.6145	0	.7269	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
180.76	218.38	120.80

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
49.76	51.01	102.50

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
25	60.04	72.90	121.41
26	60.37	72.92	120.78
27	60.37	72.56	120.20

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER.
63.274	65.247	64.245

TOTAL HEAT IN WATT-HRS= -76.47 AMBIENT CORRECTION= 3.6000 DEGREES F

************************************ WARNING ************************************
************************************ PARITY ERROR ON RECORD 1586 ************************************

MODT 49 PARAMETRIC TEST-DATE 165 STATISTICS FOR ORBIT NUMBER 429

STRING NUMBER 1

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.373	1.373	0	112600.	41.284	41.514	2.746	25.864	0	0	0	0	0	0
END	1.255	1.253	0	120100.	42.018	42.661	2.509	25.860	0	0	0	0	0	0
CHARGE														
START I1	1.389	1.390	0	120200.	42.064	42.615	2.779	81.958	0	0	0	0	0	0
END I1	1.525	1.530	0	120700.	42.064	42.752	3.055	81.966	0	0	0	0	0	0
START I2	1.497	1.497	0	120800.	42.064	42.798	2.994	50.084	0	0	0	0	0	0
END I2	1.543	1.546	0	121000.	42.064	42.844	3.090	50.090	0	0	0	0	0	0
START I3	1.458	1.467	0	121100.	42.110	42.890	2.935	20.944	0	0	0	0	0	0
END I3	1.542	1.543	0	121800.	42.156	42.798	3.090	20.966	0	0	0	0	0	0
START I4	1.447	1.446	0	121900.	42.156	42.798	2.893	4.356	0	0	0	0	0	0
END I4	1.452	1.451	0	125900.	41.284	41.514	2.903	4.330	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
40.10	47.89	119.42

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
15.52	16.24	104.67

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
1	20.05	23.93	119.38
2	20.05	23.95	119.45

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
39.290	40.138	39.689

TOTAL HEAT IN WATT-HRS= .34 AMBIENT CORRECTION= 2.0000 DEGREES F

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MODT 48 PARAMETRIC TEST-DATE 165 STATISTICS FOR ORBIT NUMBER 429

STRING NUMBER 2

DISCHARGE	C1	C2	C3	TIME	VOLT	TSR	SFV	AMP	A1	P1ANV	A2	P2ANV	A3	P3ANV
START	1.352	1.349	1.351	112600.	20.80#	33.402	4.053	48.194	0	0	0	0	0	0
END	1.190	1.187	1.190	120100.	34.009	35.738	3.567	48.176	0	0	0	0	0	0
CHARGE														
START I1	1.321	1.327	1.325	120200.	11.69#	35.795	3.973	82.080	0	0	0	0	0	0
END I1	1.545	1.559	1.553	121700.	-2.005	35.411	4.659	82.090	0	0	0	0	0	0
START I2	1.506	1.513	1.512	121800.	23.74#	35.411	4.531	49.728	0	0	0	0	0	0
END I2	1.537	1.545	1.545	122000.	9.15[illegible]	35.458	4.627	49.732	0	0	0	0	0	0
START I3	1.476	1.461	1.481	122100.	17.[illegible]	35.[illegible]	4.438	20.520	0	0	0	0	0	0
END I3	1.558	1.541	1.551	123000.	15.154	35.13[illegible]	4.656	20.536	0	0	0	0	0	0
START I4	1.456	1.454	1.456	123100.	21.17#	35.044	4.366	4.030	0	0	0	0	0	0
END I4	1.445	1.442	1.443	125900.	24.30#	33.449	4.330	4.076	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
1?7.62	129.15	120.06

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
26.92	29.55	102.18

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
4	35.87	42.56	115.76
5	35.84	43.11	120.28
6	35.91	43.08	119.96

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
32.874	37.495	33.036

TOTAL HEAT IN WATT-HRS= 62.635 AMBIENT CORRECTION= 2.0000 DEGREES F

R4-2

MODT 4R PARAMETRIC   TEST-DATE 165 STATISTICS FOR ORBIT NUMBER   429

STRING NUMBER 3

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.384	1.384	1.382	112600.	33.402	33.402	4.146	50.158	.5740	0	.4536	0	.3506	0
END	1.219	1.219	1.219	120100.	35.064	36.065	3.656	50.134	.5235	0	.4288	0	.3265	0
CHARGE														
START I1	1.345	1.348	1.346	120200.	35.178	36.065	4.039	82.448	.5957	0	.4814	0	.3602	0
END I1	1.575	1.552	1.537	121500.	34.856	35.545	4.664	82.414	.7169	0	.5543	0	.3902	0
START I2	1.490	1.480	1.483	121600.	34.850	35.551	4.461	49.730	.6542	0	.5124	0	.3768	0
END I2	1.543	1.538	1.524	121900.	34.804	35.545	4.605	49.744	.6859	0	.5412	0	.3907	0
START I3	1.567	1.566	1.549	122000.	34.757	35.458	4.682	20.686	.7008	0	.5561	0	.4002	0
END I3	1.539	1.557	1.577	123900.	34.103	34.336	4.673	20.738	.6698	0	.5397	0	.4108	0
START I4	1.485	1.490	1.496	124000.	34.103	34.298	4.471	5.640	.6319	0	.5022	0	.3769	0
END I4	1.471	1.469	1.474	125900.	33.402	33.402	4.414	5.674	.6293	0	.4954	0	.3785	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
114.23	137.33	120.22

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
30.08	31.13	103.48

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
7	38.09	45.82	120.28
8	38.07	45.80	120.31
9	38.07	45.71	120.08

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
31.927	33.075	32.511

TOTAL HEAT IN WATT-HRS= -4.64 AMBIENT CORRECTION= 2.0000 DEGREES F

A4-30

HODT-40 PARAMETRIC TESTMOATE 105 STATISTICS FOR ORBIT NUMBER 429

DISCHARGE	C1	C2	C3	TIME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	A2	PP-AV	A3	[illegible]
START	1.338	1.339	1.341	112600.	45.642	46.193	4.018	84.456	0	0	0	0	0	0
END	1.171	1.174	1.175	120100.	48.624	51.192	3.520	84.468	0	0	0	0	0	0
CHARGE														
START I1	1.317	1.315	1.314	122200.	48.716	51.313	3.945	82.611	0	0	0	0	0	0
END I1	1.528	1.518	1.529	123200.	46.565	47.890	4.562	82.622	0	0	0	0	0	0
START I2	1.482	1.484	1.481	123350.	46.555	47.895	4.447	50.956	0	0	0	0	0	0
END I2	1.534	1.521	1.529	123700.	46.514	47.752	4.561	50.968	0	0	0	0	0	0
START I3	1.455	1.466	1.458	123800.	46.459	47.7 6	4.373	21.014	0	0	0	0	0	0
END I3	1.511	1.535	1.517	125250.	45.872	45.651	4.563	21.022	0	0	0	0	0	0
START I4	1.458	1.465	1.461	125300.	45.325	46.550	4.384	4.652	0	0	0	0	0	0
END I4	1.452	1.444	1.442	125900.	45.642	46.330	4.327	4.670	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
187.34	227.46	121.42

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
50.68	52.52	103.62

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
10	62.34	75.86	121.68
11	62.47	75.86	121.43
12	62.52	75.74	121.14

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
44.725	46.881	45.709

TOTAL HEAT IN WATT-HRS 25.88 AMBIENT CORRECTION= 2.0060 DEGREES F

R-4

MODT 4R PARAMETRIC TEST-DATE 165 STATISTICS FOR ORBIT NUMBER 429

STRING NUMBER 5

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.349	1.349	0	112600.	47.202	47.793	2.689	48.750	0	0	0	0	0	0
END	1.231	1.220	0	120100.	48.714	50.455	2.450	48.740	0	0	0	0	0	0
CHARGE														
START I1	1.357	1.356	0	120200.	48.807	50.545	2.714	83.076	0	0	0	0	0	0
END I1	1.504	1.509	0	121500.	48.441	49.817	3.013	83.084	0	0	0	0	0	0
START I2	1.481	1.482	0	121600.	48.349	49.862	2.963	50.896	0	0	0	0	0	0
END I2	1.503	1.512	0	122100.	48.211	49.673	3.020	50.924	0	0	0	0	0	0
START I3	1.455	1.456	0	122200.	48.165	49.623	2.910	19.416	0	0	0	0	0	0
END I3	1.512	1.490	0	123600.	47.844	[illegible]	3.002	19.432	0	0	0	0	0	0
START I4	1.463	1.445	0	123700.	47.890	48.761	2.905	3.716	0	0	0	0	0	0
END I4	1.433	1.420	0	125900.	47.156	47.798	2.850	3.770	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
74.17	89.27	120.36

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
29.25	35.66	104.82

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
I3	37.19	44.64	120.03
I4	36.98	44.63	120.69

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
45.826	47.431	46.523

TOTAL HEAT IN WATT-HRS= -8.39 AMBIENT CORRECTION= 2.0000 DEGREES F

R4-32

MODT 48 PARAMETRIC TEST-DATE 166 STATISTICS FOR ORBIT NUMBER 429

STRING NUMBER 4

DISCHARGE	C1	C2	C3	TIME	[illegible]	[illegible]	[illegible]	AMP	A1	[illegible]	A2	[illegible]	A3	[illegible]
START	1.332	1.337	1.333	112600.	45.642	45.688	4.002	47.922	.3069	0	.3258	0	.4819	0
END	1.193	1.192	1.185	120100.	47.559	48.303	3.560	47.938	.3015	0	.3084	0	.4662	0
CHARGE														
START I1	1.322	1.328	1.324	120200.	47.661	48.359	3.980	79.672	.3420	0	.3594	0	.5322	0
END I1	1.491	1.479	1.488	121300.	47.439	47.936	4.458	79.670	.3669	0	.4012	0	.5900	0
START I2	1.476	1.461	1.471	121400.	47.284	47.936	4.407	47.886	.3691	0	.4040	0	.5938	0
END I2	1.5[illegible]	1.465	1.494	122000.	46.972	47.661	4.481	47.896	.3607	0	.3958	0	.5808	0
START I3	1.444	1.456	1.463	122100.	46.972	47.615	4.377	19.332	.3475	0	.3781	0	.5595	0
END I3	1.5[illegible]3	1.494	1.512	123800.	46.422	45.743	4.509	19.352	.3564	0	.3921	0	.5727	0
START I4	1.445	1.443	1.452	123900.	46.335	46.506	4.344	4.820	.3359	0	.3658	0	.5375	0
END I4	1.437	1.436	1.441	125900.	45.642	45.734	4.313	4.828	.3373	0	.3661	0	.5351	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
1[illegible]4.96	127.16	118.99

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
28.76	29.38	102.15

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
16	35.55	42.47	119.47
17	35.75	42.25	118.15
18	35.56	42.44	119.35

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
44.450	45.917	45.124

TOTAL HEAT IN WATT-HRS= -10.74 AMBIENT CORRECTION= .250000 DEGREES F

R 4-

MODI 4F PARAMETRIC TEST-DATE 165 STATISTICS FOR ORBIT NUMBER 429

					STRING NUMBER		7						
DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.377	1.380	1.368	112600.	67.040	66.951	4.125	19.060	0	0	0	0	0	0
END	1.280	1.282	1.274	120100.	67.579	67.713	3.836	19.054	0	0	0	0	0	0
CHARGE														
START I1	1.392	1.390	1.394	120200.	67.623	67.713	4.176	81.294	0	0	0	0	0	0
END I1	1.457	1.453	1.461	120500.	67.668	67.668	4.371	81.278	0	0	0	0	0	0
START I2	1.433	1.432	1.437	120600.	67.623	67.668	4.302	48.284	0	0	0	0	0	0
END I2	1.456	1.451	1.458	120800.	67.623	67.668	4.365	48.288	0	0	0	0	0	0
START I3	1.429	1.426	1.429	120900.	67.578	67.713	4.284	19.136	0	0	0	0	0	0
END I3	1.465	1.471	1.469	121800.	67.399	67.444	4.404	19.158	0	0	0	0	0	0
START I4	1.425	1.428	1.423	121900.	67.399	67.399	4.276	4.318	0	0	0	0	0	0
END I4	1.425	1.431	1.420	125900.	66.906	66.861	4.275	4.322	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
45.04	62.00	137.67

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
11.43	14.40	126.00

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
19	15.04	20.66	137.42
20	15.05	20.65	137.25
21	14.95	20.69	138.33

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
65.561	66.457	65.899

TOTAL HEAT IN WATT-HRS= -12.90 AMBIENT CORRECTION= 2.0000 DEGREES F

R4-34

MODE 48 PARAMETRIC TEST-DATE 186 STATISTICS FOR ORBIT NUMBER 429

STRING NUMBER 8

DISCHARGE	C1	C2	C3	TIME	OCT	TSP	SOV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.365	1.364	1.369	112600.	66.368	65.682	4.098	19.094	0	0	0	0	0	0
END	1.270	1.270	1.277	120100.	66.994	67.489	3.817	19.062	0	0	0	0	0	0
CHARGE														
START I1	1.404	1.402	1.392	120200.	66.996	67.534	4.197	83.690	0	0	0	0	0	0
END I1	1.467	1.463	1.449	120400.	67.040	67.534	4.079	83.854	0	0	0	0	0	0
START I2	1.447	1.443	1.433	120500.	67.040	67.534	4.323	50.002	0	0	0	0	0	0
END I2	1.475	1.470	1.458	120700.	67.095	67.579	4.402	50.014	0	0	0	0	0	0
START I3	1.434	1.430	1.425	120800.	66.996	67.578	4.287	19.502	0	0	0	0	0	0
END I3	1.447	1.454	1.496	121900.	66.816	67.354	4.425	19.442	0	0	0	0	0	0
START I4	1.412	1.416	1.421	122000.	66.816	67.309	4.255	4.568	0	0	0	0	0	0
END I4	1.412	1.415	1.425	125900.	66.278	66.592	4.252	4.656	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
44.88	59.78	133.21

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
11.45	13.87	121.13

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
22	14.95	19.96	133.56
23	14.94	19.93	133.35
24	14.99	19.89	132.71

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
65.022	65.650	65.319

TOTAL HEAT IN WATT-HRS= -12.96 AMBIENT CORRECTION= 0.000 DEGREES F

R 4-

MODT 4A PARAMETRIC   TEST-DATE 165 STATISTICS FOR ORBIT NUMBER   422

STRING NUMBER 9

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.313	1.311	1.316	2800.	63.991	64.439	3.949	84.630	.3995	0	.5916	0	.7139	0
END	1.14	1.156	1.152	10300.	66.814	69.193	3.447	81.826	.3751	0	.5507	0	.6407	0
CHARGE														
START I1	1.305	1.305	1.305	10400.	66.814	69.234	3.915	81.818	.4370	0	.6245	0	.7411	0
END I1	1.480	1.477	1.474	12900.	65.202	66.323	4.431	81.940	.4594	0	.6946	0	.8369	0
START I2	1.463	1.458	1.447	13000.	65.112	66.278	4.350	49.262	.4490	0	.6795	0	.8185	0
END I2	1.479	1.479	1.473	14000.	64.709	65.561	4.431	49.294	.4568	0	.6891	0	.8273	0
START I3	1.433	1.436	1.433	14100.	64.664	65.516	4.307	17.666	.4409	0	.6625	0	.7984	0
END I3	1.459	1.515	1.453	20000.	64.036	64.434	4.427	19.704	.4577	0	.7141	0	.8125	0
START I4	1.424	1.446	1.42	20100.	64.036	64.529	4.290	4.762	.4426	0	.6680	0	.7880	0
END I4	1.424	1.446	1.42	20100.	64.036	64.529	4.290	4.762	.4426	0	.6680	0	.7880	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
179.82	22[illegible].70	122.73

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
49.15	51.49	104.76

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
25	59.74	73.66	123.30
26	60.02	73.66	122.72
27	60.36	73.37	122.17

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
63.408	64.933	64.123

TOTAL HEAT IN WATT-HRS= -28.64 AMBIENT CORRECTION= 2.0000 DEGREES F

*************************ALARM ************************

STRING 9 SHUTDOWN TIME= 23800

R4-36

MODT 4? PARAMETRIC TEST-DATE 170 STATISTICS FOR ORBIT NUMBER 473

STRING NUMBER 1

ALARM CONDITION EXISTS

DISCHARGE	C1	C2	C3	TIME	CLI	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.382	1.363	[illegible]	225100.	36.159	36.813	2.765	25.848	0	0	0	0	0	0
END	1.252	1.253	[illegible]	232600.	36.860	37.888	2.504	25.838	0	0	0	0	0	0
CHARGE														
START I1	1.392	1.354	[illegible]	232700.	36.860	37.935	2.786	82.006	0	0	0	0	0	0
END I1	1.553	1.559	[illegible]	233200.	36.467	37.981	3.111	81.964	0	0	0	0	0	0
START I2	1.517	1.519	[illegible]	233300.	36.962	37.981	3.035	50.072	0	0	0	0	0	0
END I2	1.541	1.546	[illegible]	233400.	36.907	38.075	3.086	50.082	0	0	0	0	0	0
START I3	1.562	1.576	[illegible]	233500.	36.953	38.121	3.137	20.912	0	0	0	0	0	0
END I3	1.576	1.586	[illegible]	234400.	37.000	38.121	3.163	20.942	0	0	0	0	0	0
START I4	1.492	1.454	[illegible]	234500.	37.000	38.121	2.986	4.368	0	0	0	0	0	0
END I4	1.464	1.463	[illegible]	2400.	36.259	36.4?7	2.927	4.322	0	0	0	0	0	0

********** WARNING CHARGE CYCLE TIMING ABNORMAL **********

WATT-HOURS OUT	WATT-HOURS IN	PERCENT RETURN
63.79	47.76	119.19

AMP-HOURS OUT	AMP-HOURS IN	PERCENT RETURN
15.51	16.02	103.33

	WATT-HOURS OUT	WATT-HOURS IN	PERCENT RETURN
1	20.04	23.57	119.11
2	20.05	23.91	119.26

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
35.037	35.632	35.494

TOTAL HEAT IN WATT-HRS= ??.?1 AMBIENT CORRECTION= 0.0000 DEGREES F

R4-

MODT 40 PARAMETRIC TEST-DATE 170 STATISTICS FOR ORBIT NUMBER 473

STRING NUMBER 2

****

ALARM CONDITION EXISTS

DISCHARGE	C1	C2	C3	TIME	OLT	TSA	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.334	1.326	1.329	225100.	32.421	34.757	3.989	80.204	0	0	0	0	0	0
END	1.149	1.145	1.147	232600.	34.710	39.183	3.441	80.172	0	0	0	0	0	0
CHARGE														
START I1	[illegible]	1.310	1.308	232700.	34.330	39.196	3.924	82.144	0	0	0	0	0	0
END I1	1.597	1.6[illegible]5	1.6[illegible]6	235600.	32.751	36.6[illegible]	4.608	82.210	0	0	0	0	0	0
START I2	1.556	1.563	1.562	235700.	32.841	36.673	4.682	49.848	0	0	0	0	0	0
END I2	1.594	1.601	1.603	[illegible]	32.701	36.673	4.799	49.862	0	0	0	0	0	0
START I3	1.527	1.530	1.531	100.	32.421	36.626	4.588	20.630	0	0	0	0	0	0
END I3	1.621	1.591	1.598	1300.	31.819	35.832	4.810	20.672	0	0	0	0	0	0
START I4	1.513	1.4[illegible]	1.493	1400.	32.047	35.785	4.487	4.136	0	0	0	0	0	0
END I4	1.450	1.445	1.445	2400.	53.510	34.897	4.341	4.154	0	0	0	0	0	0

********** WARNING CHARGE CYCLE TIMING ABNORMAL **********

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
174.52	218.61	125.38

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
48.13	49.45	102.74

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
4	58.27	72.82	124.97
5	58.[illegible]7	73.02	125.74
6	58.18	72.97	125.42

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
3[illegible].794	34.664	33.762

TOTAL HEAT IN WATT-HRS=-295.55 AMBIENT CORRECTION= 2.0000 DEGREES F

MODT 49 PARAMETRIC TEST-DATE 170 STATISTICS FOR ORBIT NUMBER 473

STRING NUMBER 3

DISCHARGE	C1	C2	C3	TIME	OLT	TSP	SCV	[illegible]	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.392	1.385	1.387	225100.	34.757	35.684	4.166	50.138	.6490	0	.5063	0	.3924	0
END	1.209	1.211	1.210	232600.	36.306	37.6 7	3.630	50.126	.5978	0	.4750	0	.3650	0
CHARGE														
START I1	1.336	1.328	1.336	232700.	36.299	37.654	4.009	92.436	.6628	0	.5284	0	.4006	0
END I1	1.620	1.582	1.561	234200.	35.832	36.953	4.763	92.414	.8150	0	.6160	0	.4486	0
START I2	1.514	1.511	1.563	234300.	35.925	36.953	4.528	49.742	.7338	0	.5739	0	.4232	0
END I2	1.596	1.597	1.569	234600.	36.065	37.374	4.761	49.750	.7863	0	.6134	0	.4496	0
START I3	1.475	1.462	1.478	234700.	36.065	37.047	4.436	20.700	.7008	0	.5501	0	.4089	0
END I3	1.566	1.589	1.614	300.	35.551	36.519	4.769	20.716	.7584	0	.6092	0	.4756	0
START I4	1.494	1.493	1.507	400.	35.551	35.972	4.487	5.626	.7068	0	.5529	0	.4195	0
END I4	1.479	1.477	1.482	2400.	34.991	35.178	4.439	5.672	.7063	0	.5496	0	.4232	0

********** WARNING CHARGE CYCLE TIMING ABNORMAL **********

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
114.04	146.14	128.14

AMP-HOURS OUT	AMP-HOURS IN.	PERCENT RETURN
[illegible]	32.93	109.48

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
7	38.02	48.79	128.33
8	38.03	48.73	128.15
9	38.00	48.61	127.94

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
33.841	34.009	[illegible]

TOTAL HEAT IN WATT-HRS= 1.92 AMBIENT CORRECTION= 2.0000 DEGREES F

R4-3

MODT 4- PARAMETRIC   TEST-DATE 170 STATISTICS FOR ORBIT NUMBER   473

STRING NUMBER   4

****

ALARM CONDITION EXISTS

DISCHARGE	C1	C2	C3	TIME	CLT	TSW	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.33[illegible]	1.331	1.334	225100.	45.917	46.697	3.995	84.444	0	0	0	0	0	0
END	1.161	1.164	1.166	232600.	49.037	51.854	3.492	84.454	0	0	0	0	0	0
CHARGE														
START I1	1.3[illegible]	1.307	1.3[illegible]7	232700.	49.177	51.935	3.923	82.584	0	0	0	0	0	0
END I1	1.52[illegible]	1.519	1.518	235700.	47.019	49.522	4.557	82.592	0	0	0	0	0	0
START I2	1.48[illegible]	1.482	1.48[illegible]	235800.	47.[illegible]19	48.532	4.442	50.942	0	0	0	0	0	0
END I2	1.52[illegible]	1.519	1.519	200.	46.881	48.3[illegible]3	4.559	50.948	0	0	0	0	0	0
START I3	1.454	1.458	1.456	300.	46.881	48.257	4.369	20.988	0	0	0	0	0	0
END I3	1.5[illegible]6	1.532	1.516	1600.	46.335	47.294	4.559	21.012	0	0	0	0	0	0
START I4	1.44[illegible]	1.45[illegible]	1.452	1700.	46.28[illegible]	47.[illegible]	4.353	4.658	0	0	0	0	0	0
END I4	1.434	1.436	1.436	2400.	46.[illegible]55	46.7[illegible]9	4.306	4.676	0	0	0	0	0	0

********** WARNING CHARGE CYCLE TIMING ABNORMAL **********

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
1[illegible]6.65	[illegible]25.63	12[illegible].88

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
50.68	52.23	103.06

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
10	62.11	75.23	121.11
11	62.23	75.24	120.91
12	62.31	75.16	120.62

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
45.[illegible]46	47.110	46.[illegible]72

TOTAL HEAT IN WATT-HRS= -22.63 AMBIENT CORRECTION= 2.0000 DEGREES F

R4-40

MODT 40 PARAMETRIC TEST-DATE 170 STATISTICS FOR ORBIT NUMBER 473

STRING NUMBER 4

DISCHARGE	C1	C2	C3	TIME	OUT	TSR	SCV	AMP	S1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
START	1.371	1.365	0	225100.	50.400	50.409	2.736	19.816	0	0	0	0	0	0
END	1.276	1.273	0	232600.	51.279	51.5[illegible]0	2.549	19.794	0	0	0	0	0	0
CHARGE														
START I1	1.391	1.392	0	232700.	51.318	51.500	2.763	83.254	0	0	0	0	0	0
END I1	1.449	1.45[illegible]	0	232900.	51.319	51.500	2.899	83.252	0	0	0	0	0	0
START I2	1.436	1.435	0	233000.	51.274	51.455	2.871	51.100	0	0	0	0	0	0
END I2	1.4[illegible]	1.461	0	233200.	51.310	51.455	2.921	51.100	0	0	0	0	0	0
START I3	1.417	1.415		233300.	51.279	51.[illegible]	2.833	19.57[illegible]	0	0	0	0	0	0
END I3	1.457	1.453		234100.	51.272	51.318	2.91[illegible]	19.586	0	0	0	0	0	0
START I4	1.419	1.414	0	234200.	51.273	51.279	2.833	3.890	0	0	0	0	0	0
END I4	1.421	1.416	0	[illegible]2400.	50.[illegible]	5[illegible].545	2.835	3.930	0	0	0	0	0	0

********** WARNING CHARGE CYCLE TIMING ABNORMAL **********

WATT-HOURS OUT	WATT-HOURS IN	PERCENT RETURN
31.04	36.90	118.87

AMP-HOURS OUT	AMP-HOURS IN	PERCENT RETURN
[illegible]	12.90	108.60

	WATT-HOURS OUT	WATT-HOURS IN	PERCENT RETURN
I3	15.55	18.46	118.72
I4	15.50	18.44	119.01

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
48.670	49.587	49.103

TOTAL HEAT IN WATT-HRS= -0.86 AMBIENT CORRECTION= 2.0000 DEGREES F

R.4-4

MCOT 40 PARAMETRIC TEST-DATE 170 STATISTICS FOR ORBIT NUMBER 473

STRING NUMBER 7

DISCHARGE	C1	C2	C3	TIME	OLT	TSR	SCV	AMP	A1	P1-MV	A2	P2-MV	A3	P3-MV
START	1.381	1.384	1.371	225100.	67.117	67.579	4.136	19.058	0	0	0	0	0	0
END	1.275	1.270	1.273	2328[illegible].	67.546	68.161	3.827	19.054	0	0	0	0	0	0
CHARGE														
START I1	1.366	1.365	1.392	232700.	67.570	68.161	4.162	81.286	0	0	0	0	0	0
END I1	1.472	1.470	1.482	233100.	67.489	68.117	4.424	81.272	0	0	0	0	0	0
START I2	1.458	1.457	1.466	233200.	67.534	68.117	4.381	48.274	0	0	0	0	0	0
END I2	1.479	1.475	1.465	233400.	67.534	68.072	4.439	48.292	0	0	0	0	0	0
START I3	1.459	1.456	1.462	233500.	67.489	68.117	4.377	13.148	0	0	0	0	0	0
END I3	1.493	1.5[illegible]5	1.495	234300.	67.399	67.982	4.493	13.176	0	0	0	0	0	0
START I4	1.462	1.471	1.459	234400.	67.354	67.902	4.392	4.335	0	0	0	0	0	0
END I4	1.428	1.433	1.471	2400.	67.309	67.579	4.282	4.358	0	0	0	0	0	0

********** WARNING CHARGE CYCLE TIMING ABNORMAL **********

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
45.04	62.68	139.17

AMP-HOURS OUT	AMP-HOURS IN .	PERCENT RETURN
11.43	14.46	126.48

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
19	15.02	20.87	138.91
20	15.06	20.88	138.72
21	14.96	20.93	139.88

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
65.695	66.413	65.993

TOTAL HEAT IN WATT-HRS= -5.23 AMBIENT CORRECTION= 2.0000 DEGREES F

R4-

MODI 49 PARAMETRIC TEST-DATE LTD STATISTICS FOR ORBIT NUMBER 651

				STRING NUMBER				8						
DISCHARGE	C1	C2	C3	TIME	VOLT	TSR	SCV	AMP	A1	B1-MV	A2	B2-MV	A3	B3-MV
START	1.365	1.365	1.372	122300.	68.251	68.386	4.104	19.112	0	0	0	0	0	0
END	1.267	1.266	1.278	125800.	68.744	69.1[illegible]3	3.814	19.086	0	0	0	0	0	0
CHARGE														
START I1	1.464	1.401	1.387	125900.	68.746	69.103	4.191	83.820	0	0	0	0	0	0
END I1	1.52[illegible]	1.514	1.478	135300.	68.706	69.058	4.542	83.852	0	0	0	0	0	0
START I2	1.464	1.479	1.455	130400.	68.656	69.193	4.418	50.022	0	0	0	0	0	0
END I2	1.52[illegible]	1.519	1.478	130600.	68.616	69.149	4.526	50.022	0	0	0	0	0	0
START I3	1.45[illegible]	1.449	1.436	130700.	68.566	69.193	4.339	19.544	0	0	0	0	0	0
END I3	1.49[illegible]	1.484	1.563	131700.	68.43[illegible]	69.[illegible]	4.532	19.554	0	0	0	0	0	0
START I4	1.43[illegible]	1.427	1.454	131800.	68.520	68.95[illegible]	4.312	4.626	0	0	0	0	0	0
END I4	1.415	1.414	1.43[illegible]	135600.	68.206	68.490	4.259	4.708	0	0	0	0	0	0

WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
44.[illegible]7	6[illegible].42	154.38

AMP-HOURS OUT	AMP-HOURS IN..	PERCENT RETURN
11.46	15.88	138.58

	WATT-HOURS OUT	WATT-HOURS IN.	PERCENT RETURN
22	14.97	23.22	155.11
23	14.97	23.16	154.74
24	15.03	23.04	153.30

THERMAL INFORMATION - INLET TEMPERATURE IN DEG F

LOW	HIGH	AVER
65.874	66.368	66.123

TOTAL HEAT IN WATT-HRS = 2.71 AMBIENT CORRECTION = 2.0000 DEGREES F

R4-

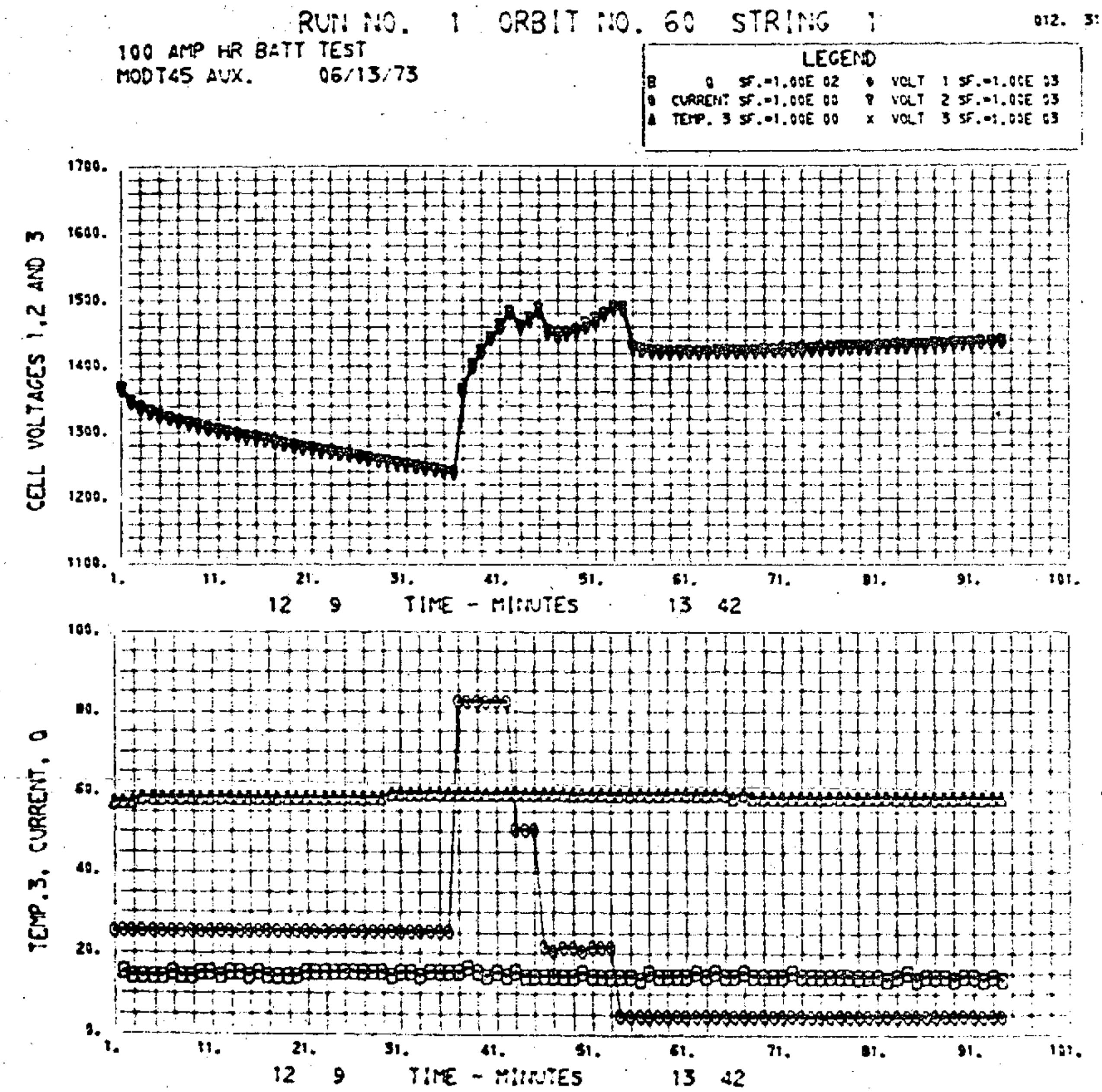
APPENDIX R-5

PARAMETRIC CELL CHARACTERIZATION

COMPUTER PLOTS OF STABILIZED CELL CHARACTERISTICS

FOR EACH STRING AT EACH TEST CONDITION

(MOD T 45 - MOD T 49)



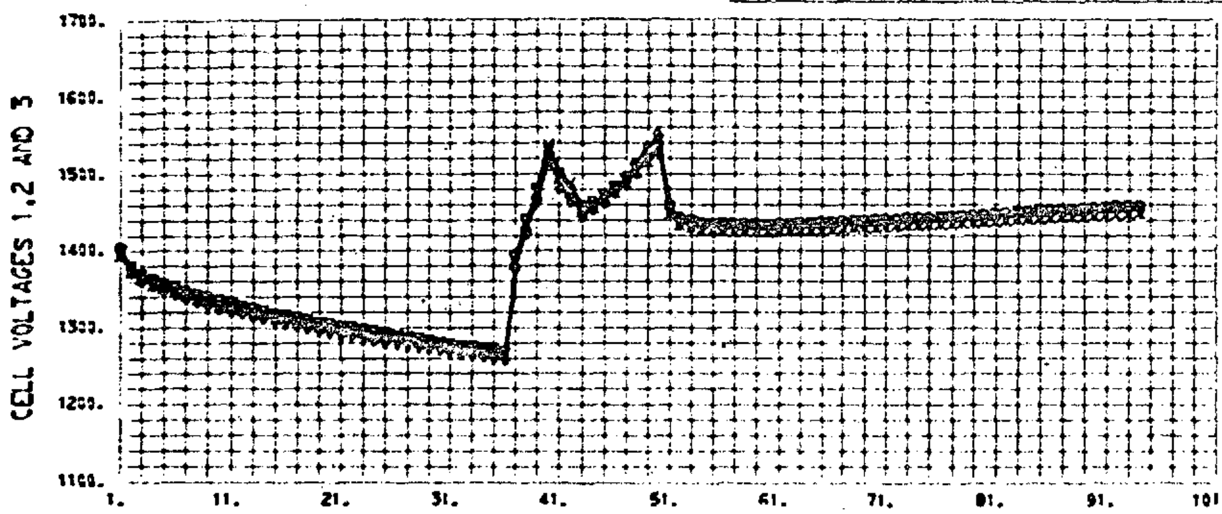
PRECEDING PAGE BLANK NOT FILMED

RUN NO. 1 ORBIT NO. 60 STRING 2 012. 32

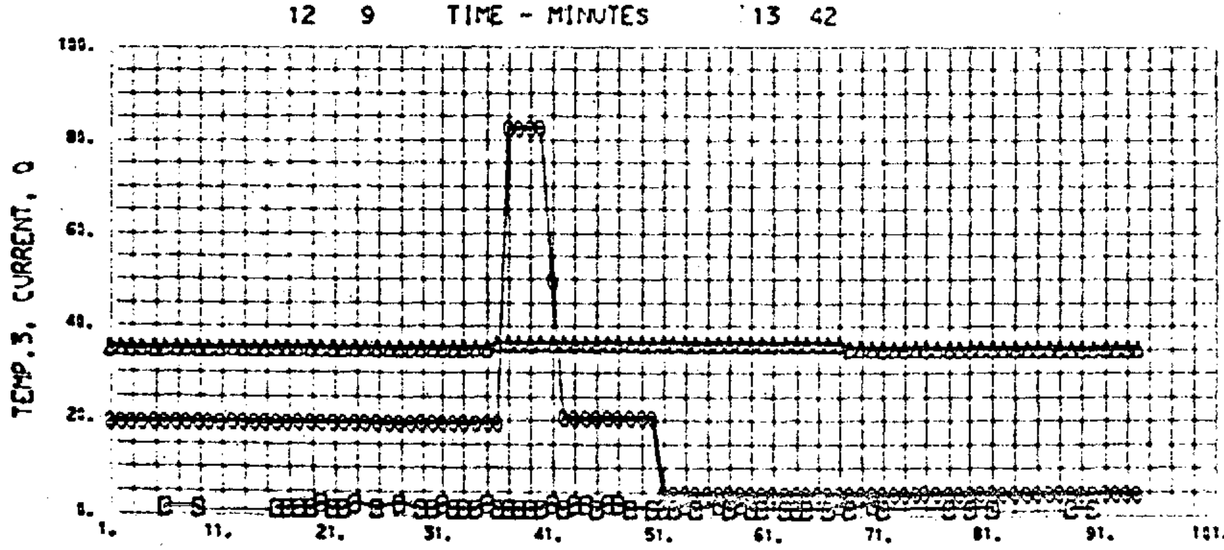
100 AMP HR BATT TEST
MODT45 AUX. 06/13/73

LEGEND

B	Q	SF.=1.00E 02	+	VOLT 1	SF.=1.00E 03
⊕	CURRENT	SF.=1.00E 00	∇	VOLT 2	SF.=1.00E 03
▲	TEMP. 3	SF.=1.00E 00	X	VOLT 3	SF.=1.00E 03



12 9 TIME - MINUTES 13 42



12 9 TIME - MINUTES 13 42

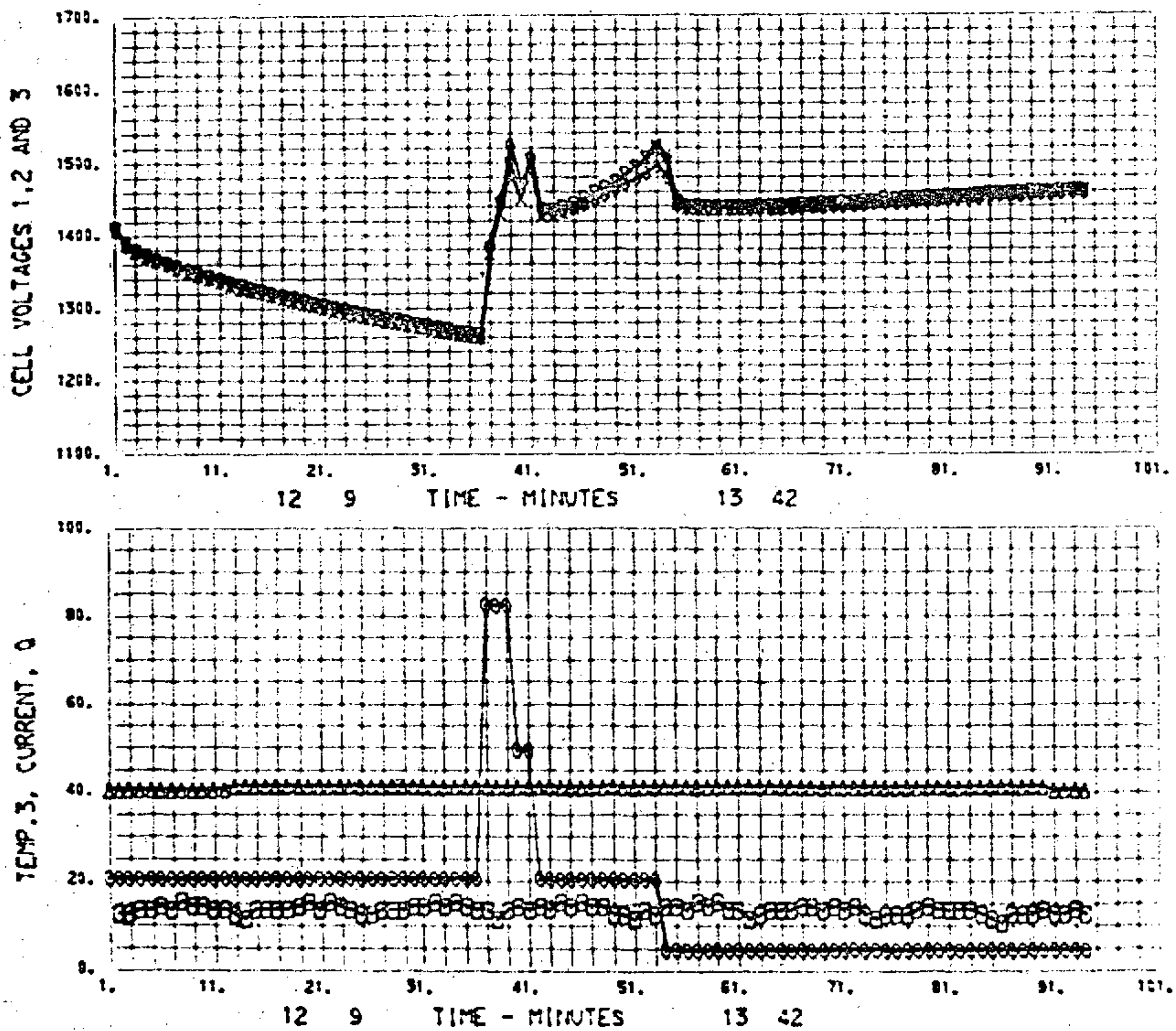
RS-2

RUN NO. 1 ORBIT NO. 60 STRING 3 912. 33

100 AMP HR BATT TEST
MODT45 AUX. 06/13/73

LEGEND

Q	SF.=1.00E 02	VOLT 1	SF.=1.00E 03
CURRENT	SF.=1.00E 00	VOLT 2	SF.=1.00E 03
TEMP. 3	SF.=1.00E 00	VOLT 3	SF.=1.00E 03

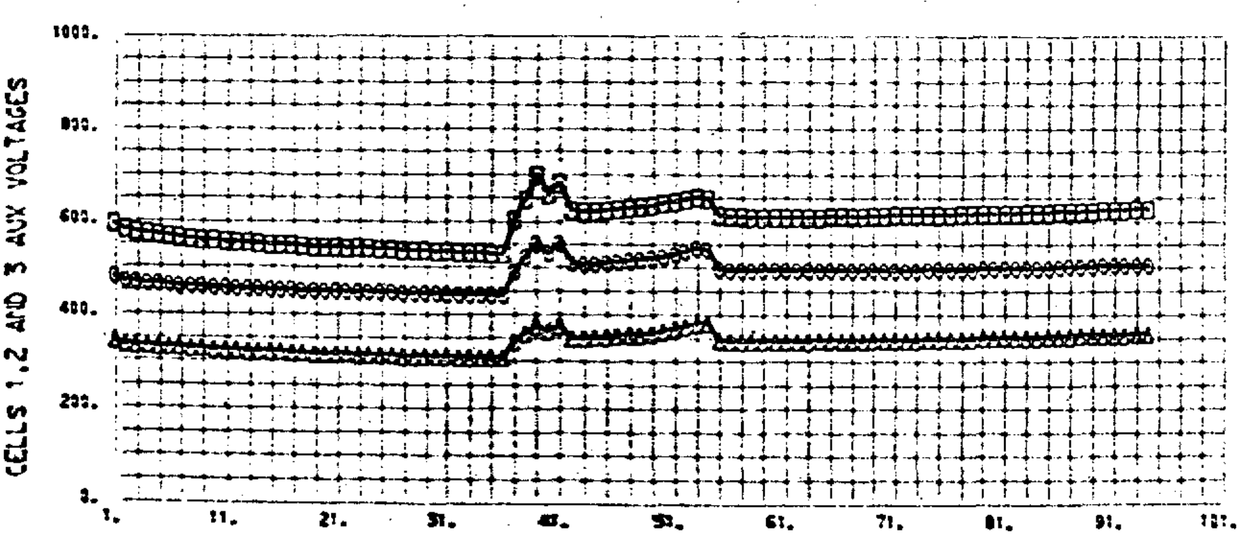


R5-3

RUN NO. 1 ORBIT NO. 60 STRING 3 012. 34

100 AMP HR BATT TEST
MODT45 AUX. 06/13/73

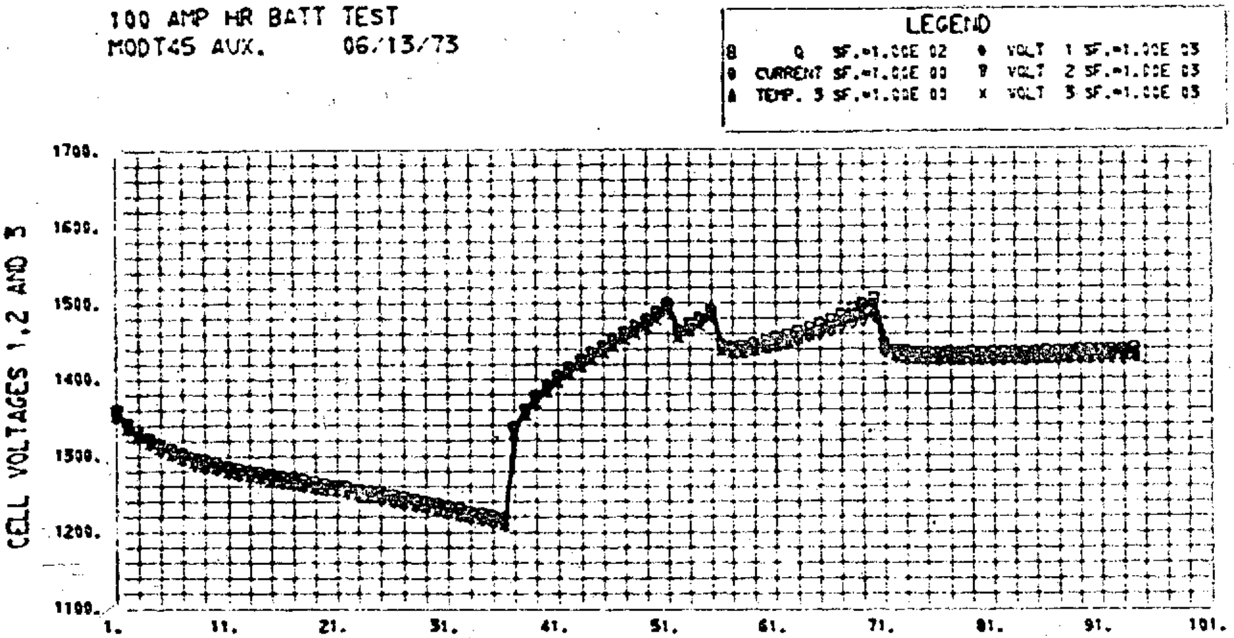
LEGEND
AUX. 1 SF.=1.00E 03
AUX. 2 SF.=1.00E 03
AUX. 3 SF.=1.00E 03

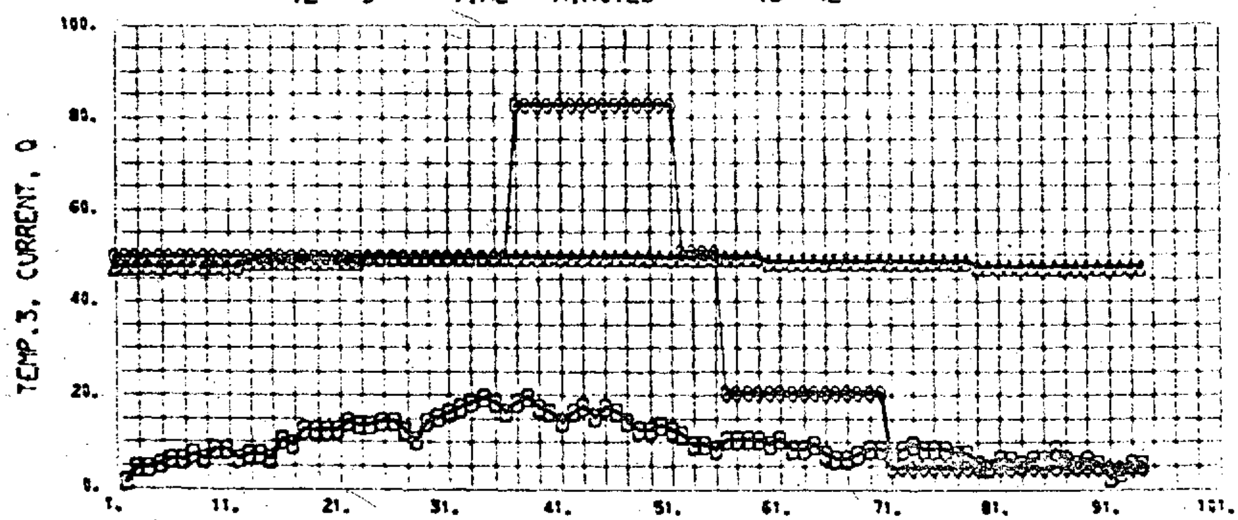


RE-4

RUN NO. 1 ORBIT NO. 60 STRING 4 012. 35

100 AMP HR BATT TEST
MODT45 AUX. 06/13/73

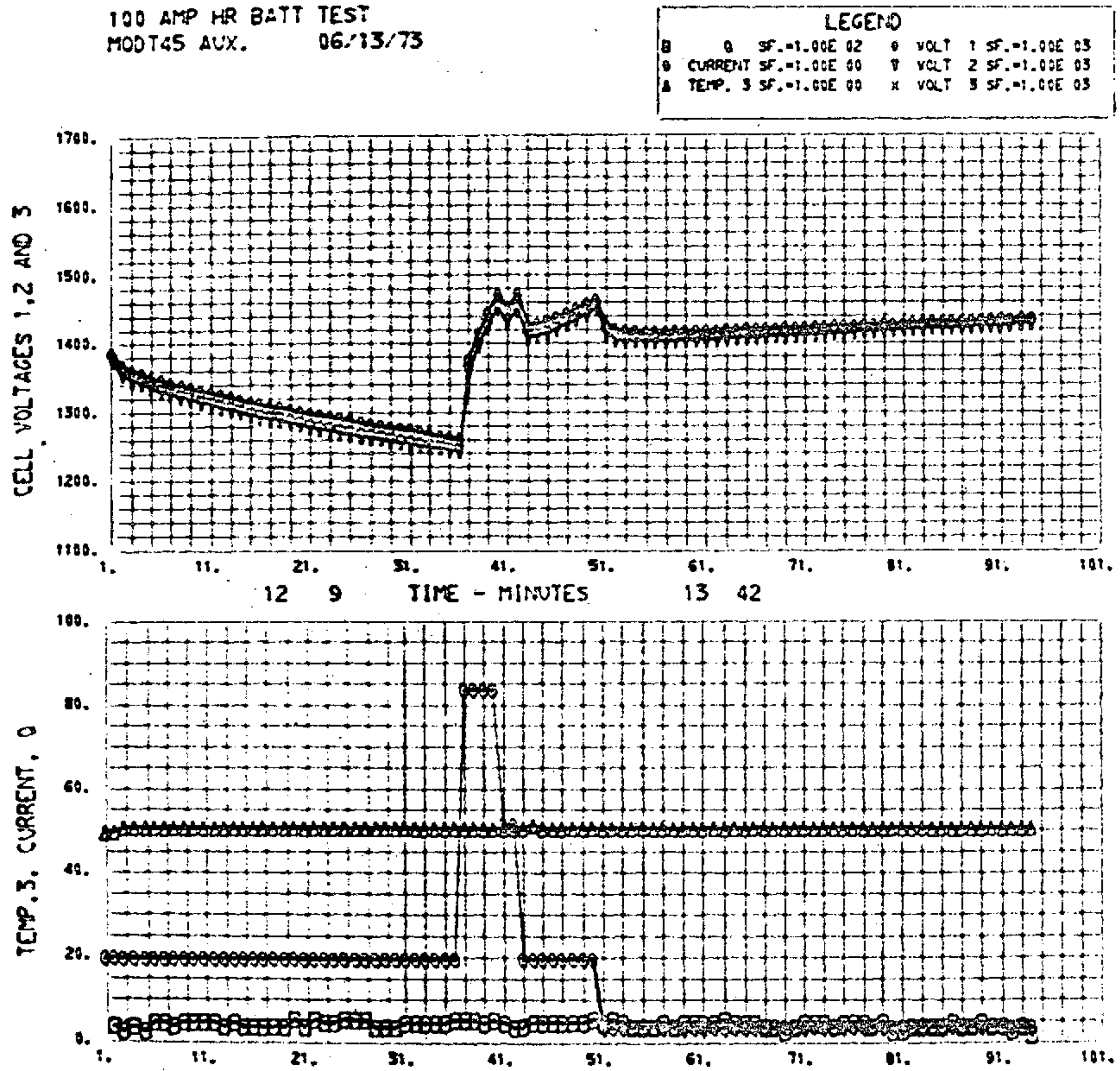




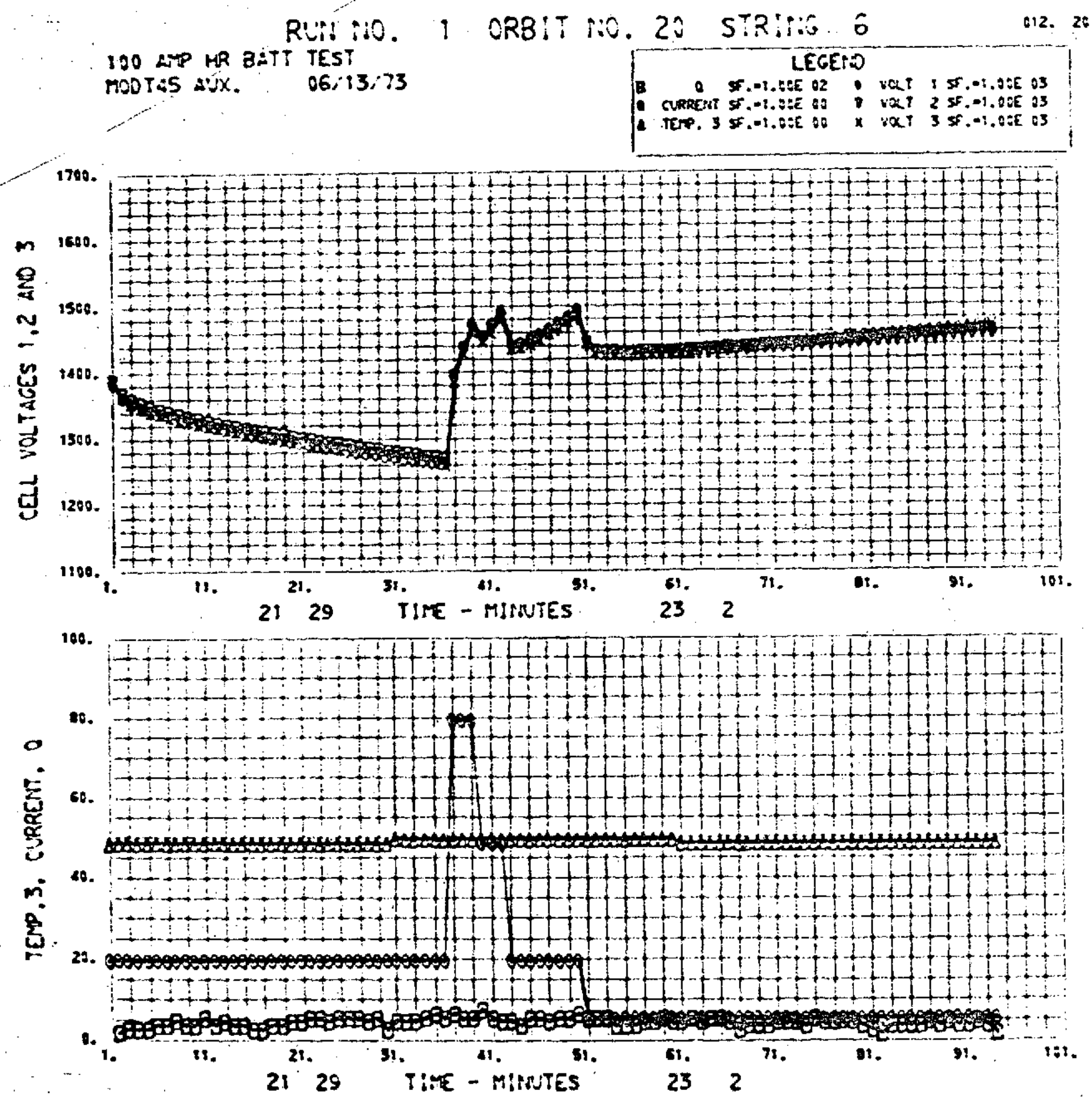
RB-5

RUN NO. 1 ORBIT NO. 60 STRING 5 012. 56

100 AMP HR BATT TEST
MODT45 AUX. 06/13/73



RS-6

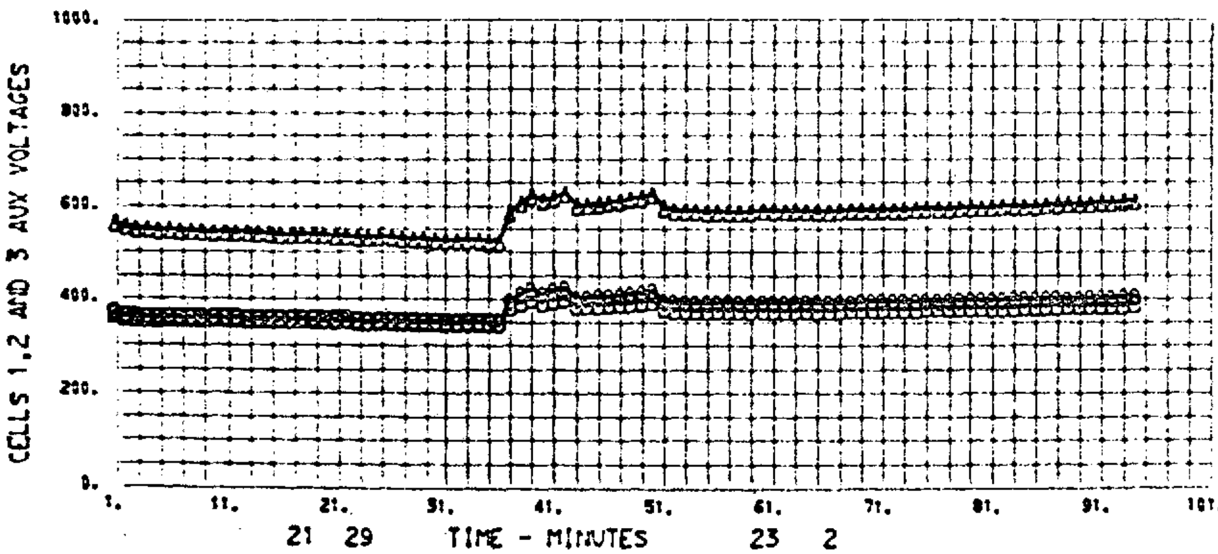


RUN NO. 1 ORBIT NO. 20 STRING 6
012. 20
100 AMP HR BATT TEST
MODT4S AUX. 06/13/73
LEGEND
CELL VOLTAGES 1,2 AND 3
TIME - MINUTES
TEMP,3, CURRENT, Q

RB-7

RUN NO. 1 ORBIT NO. 20 STRING 6 012. 21

100 AMP HR BATT TEST
MODT45 AUX. 06/13/73

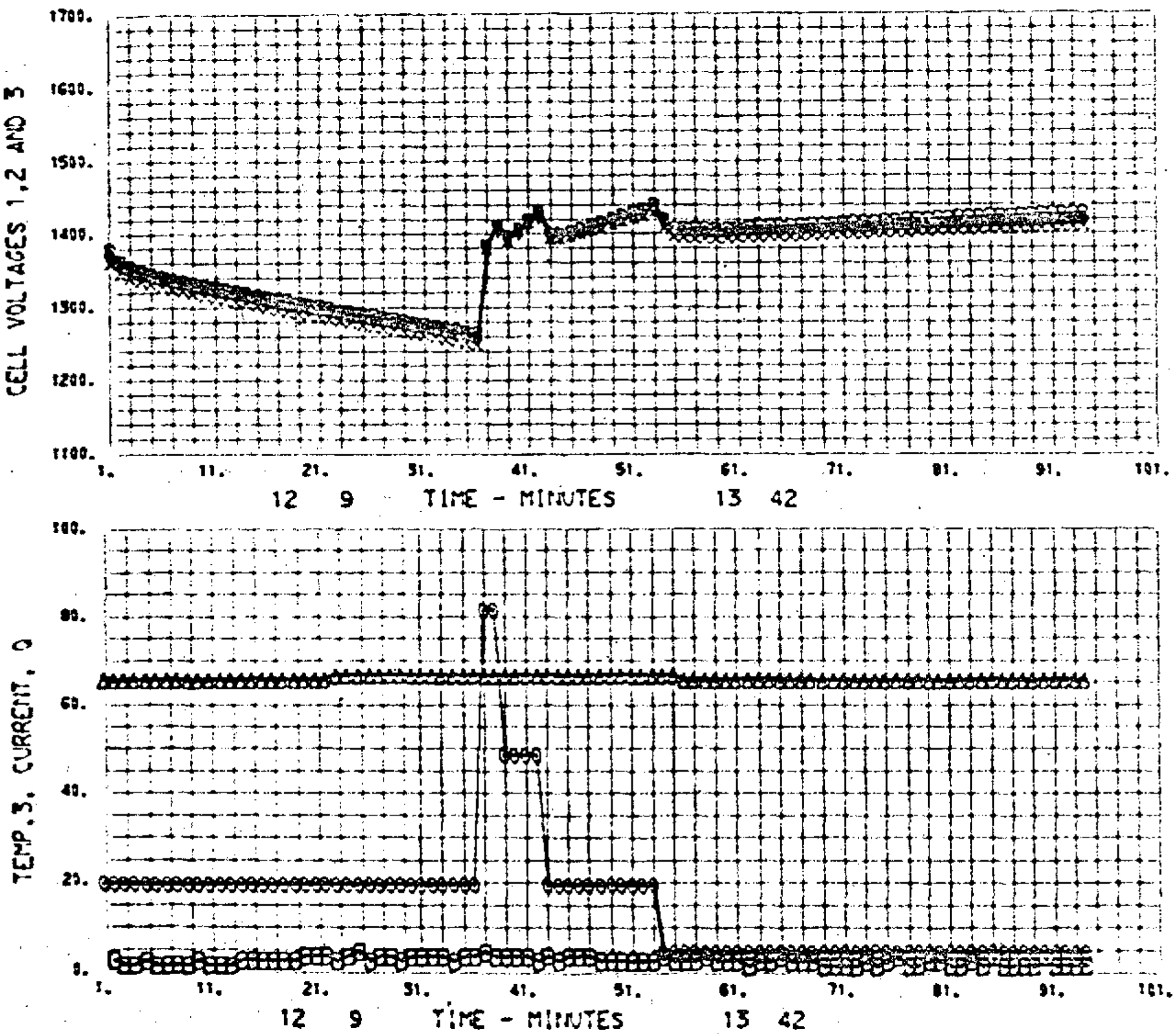


RS-8

RUN NO. 1 ORBIT NO. 60 STRING 7 012. 57

100 AMP HR BATT TEST
MODT45 AUX. 06/13/73

LEGEND
Q SF.=1.00E 02 VOLT 1 SF.=1.00E 03
CURRENT SF.=1.00E 00 VOLT 2 SF.=1.00E 03
TEMP. 3 SF.=1.00E 00 X VOLT 3 SF.=1.00E 03

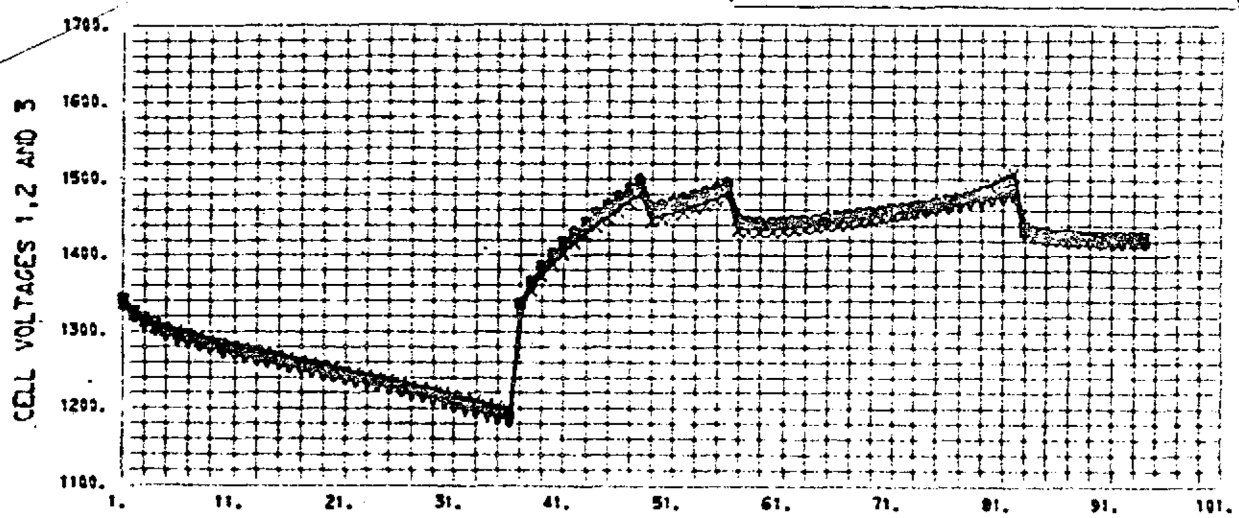


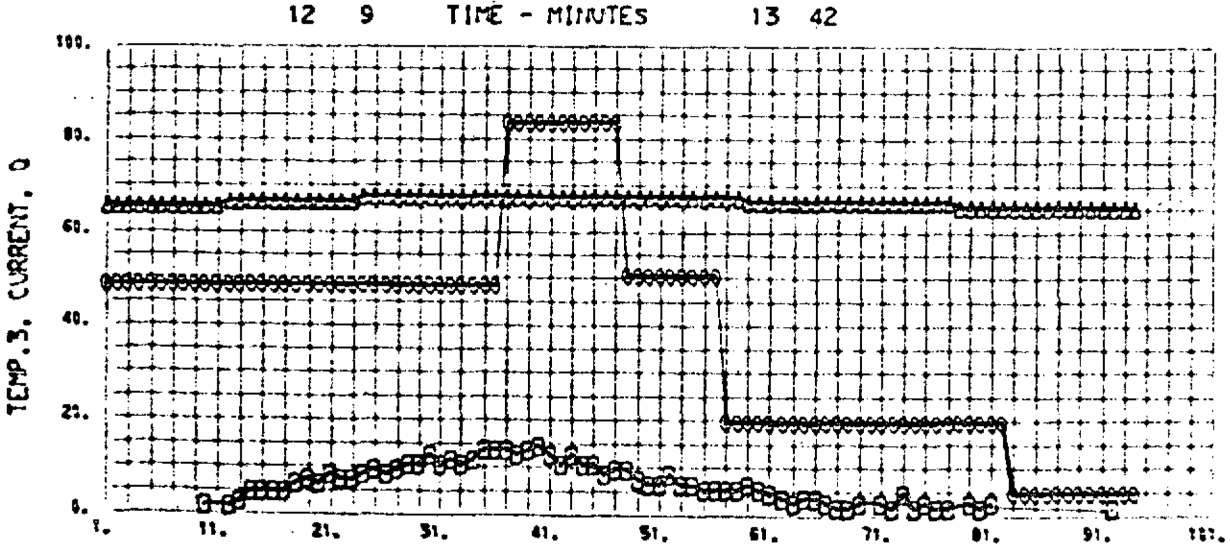
R5-9

RUN NO. 1 ORBIT NO. 60 STRING 8 012. 38

100 AMP HR BATT TEST
MODT45 AUX. 06/13/73

LEGEND
Q SF.=1.00E 02 VOLT 1 SF.=1.00E 03
CURRENT SF.=1.00E 00 VOLT 2 SF.=1.00E 03
TEMP. 3 SF.=1.00E 00 X VOLT 3 SF.=1.00E 03

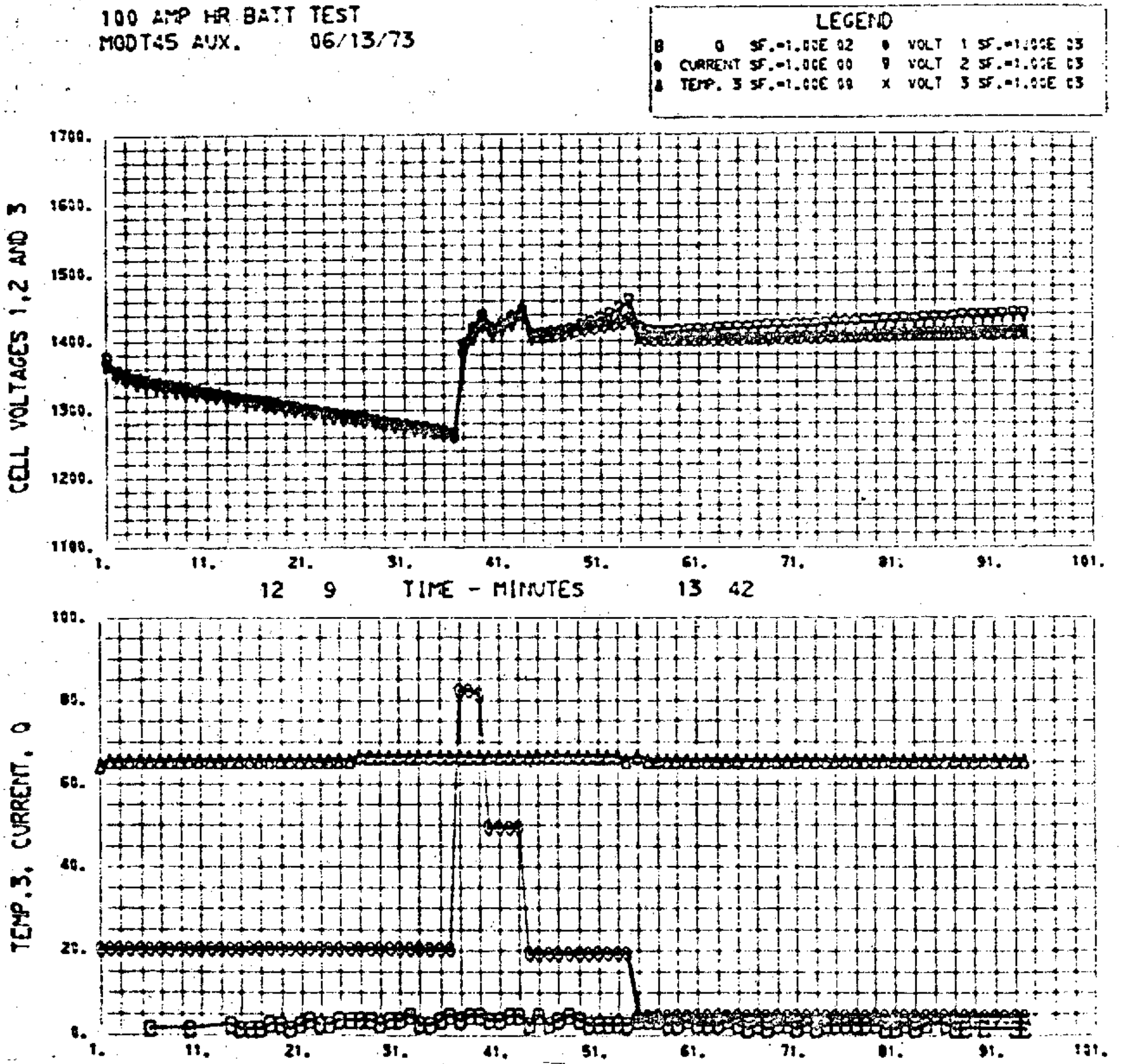




RS-10

RUN NO. 1 ORBIT NO. 60 STRING 9 012. 39

100 AMP HR BATT TEST
MODT45 AUX. 06/13/73

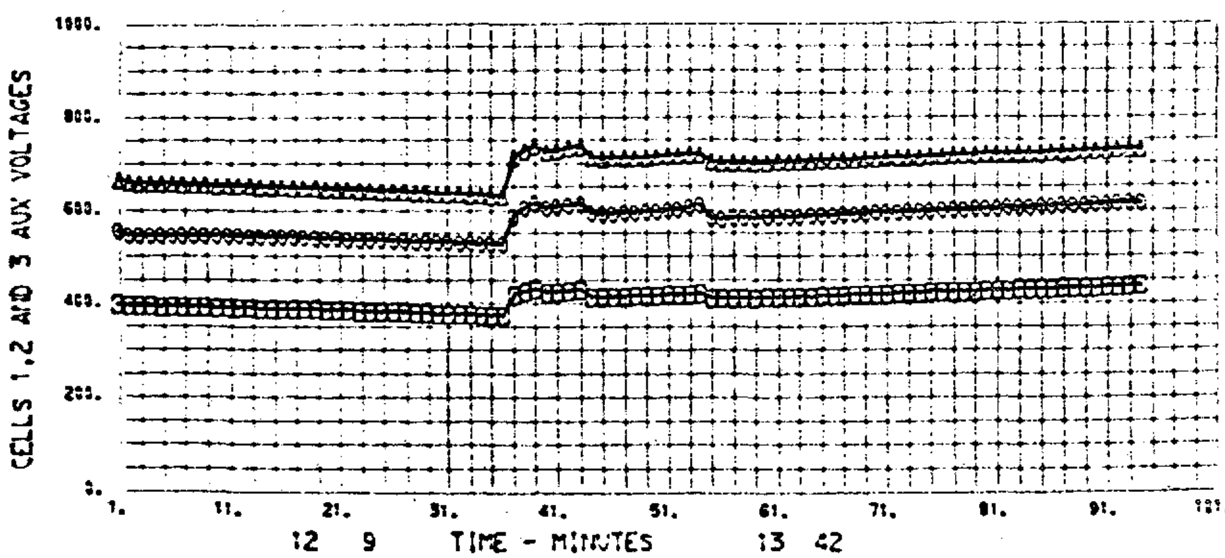


RS-11

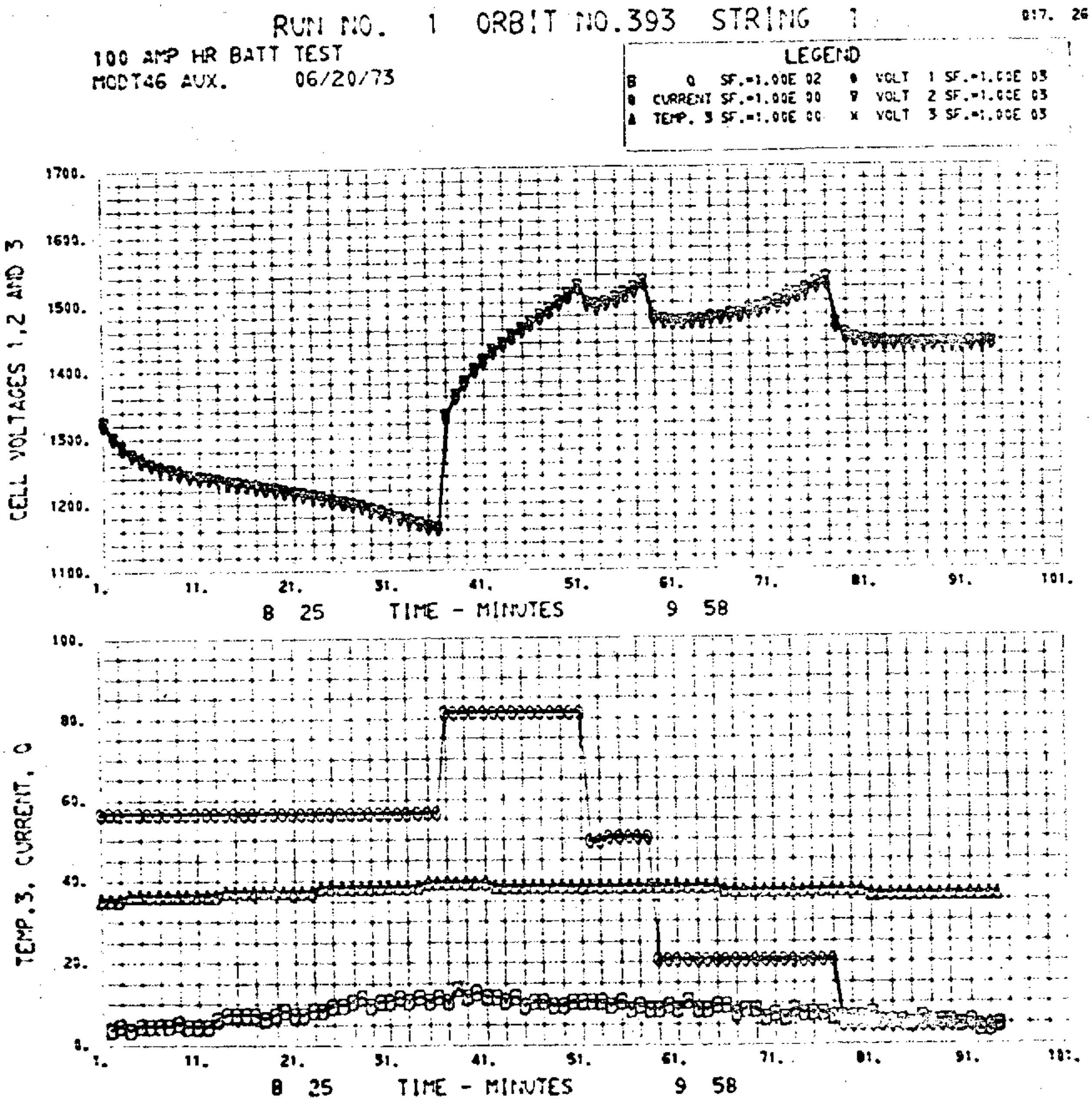
RUN NO. 1 ORBIT NO. 60 STRING 9 012. 42

100 AMP HR BATT TEST
MOD745 AUX. 06/13/73

LEGEND
B AUX. 1 SF.=1.00E 03
● AUX. 2 SF.=1.00E 03
▲ AUX. 3 SF.=1.00E 03

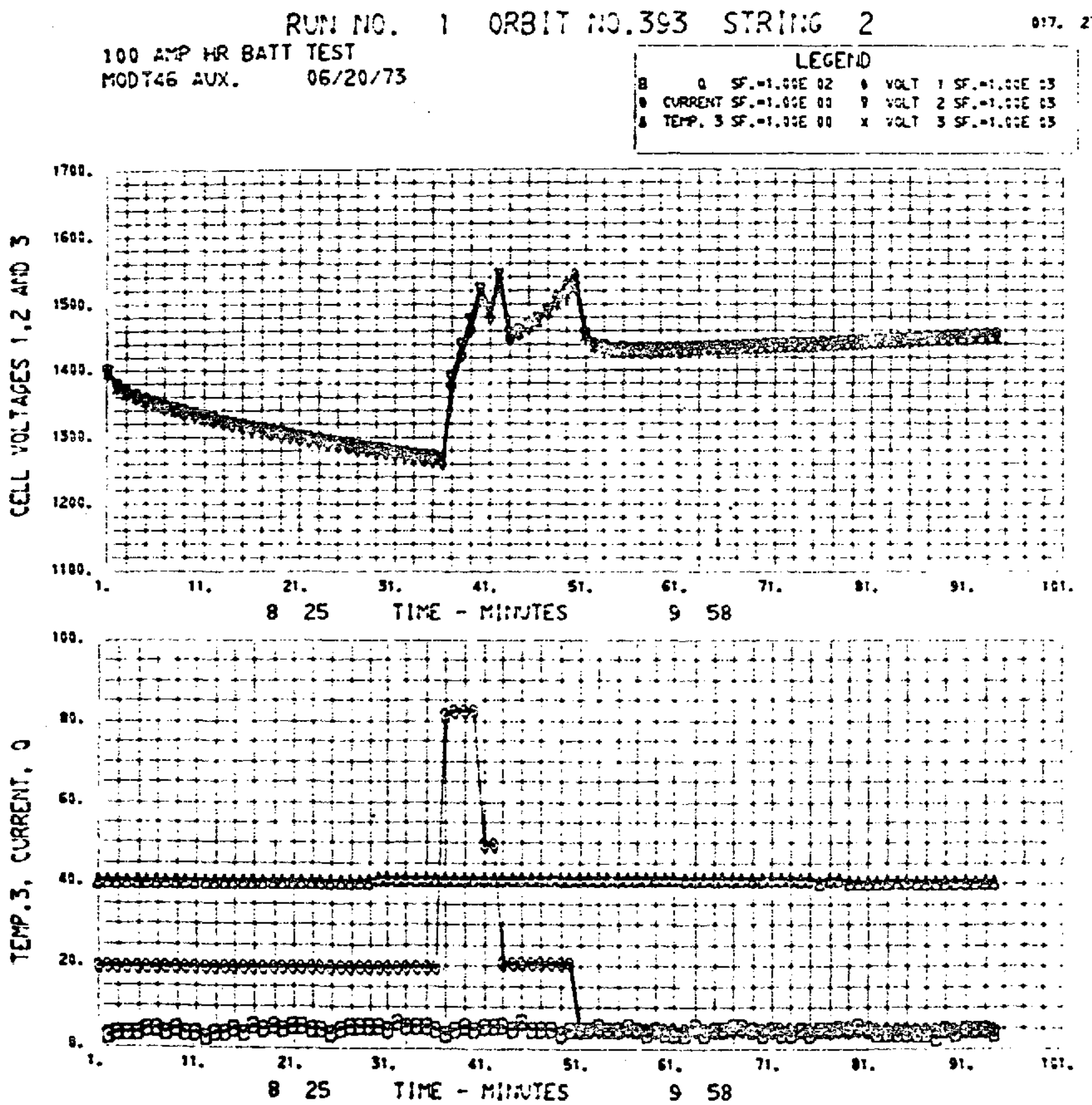


R5-12

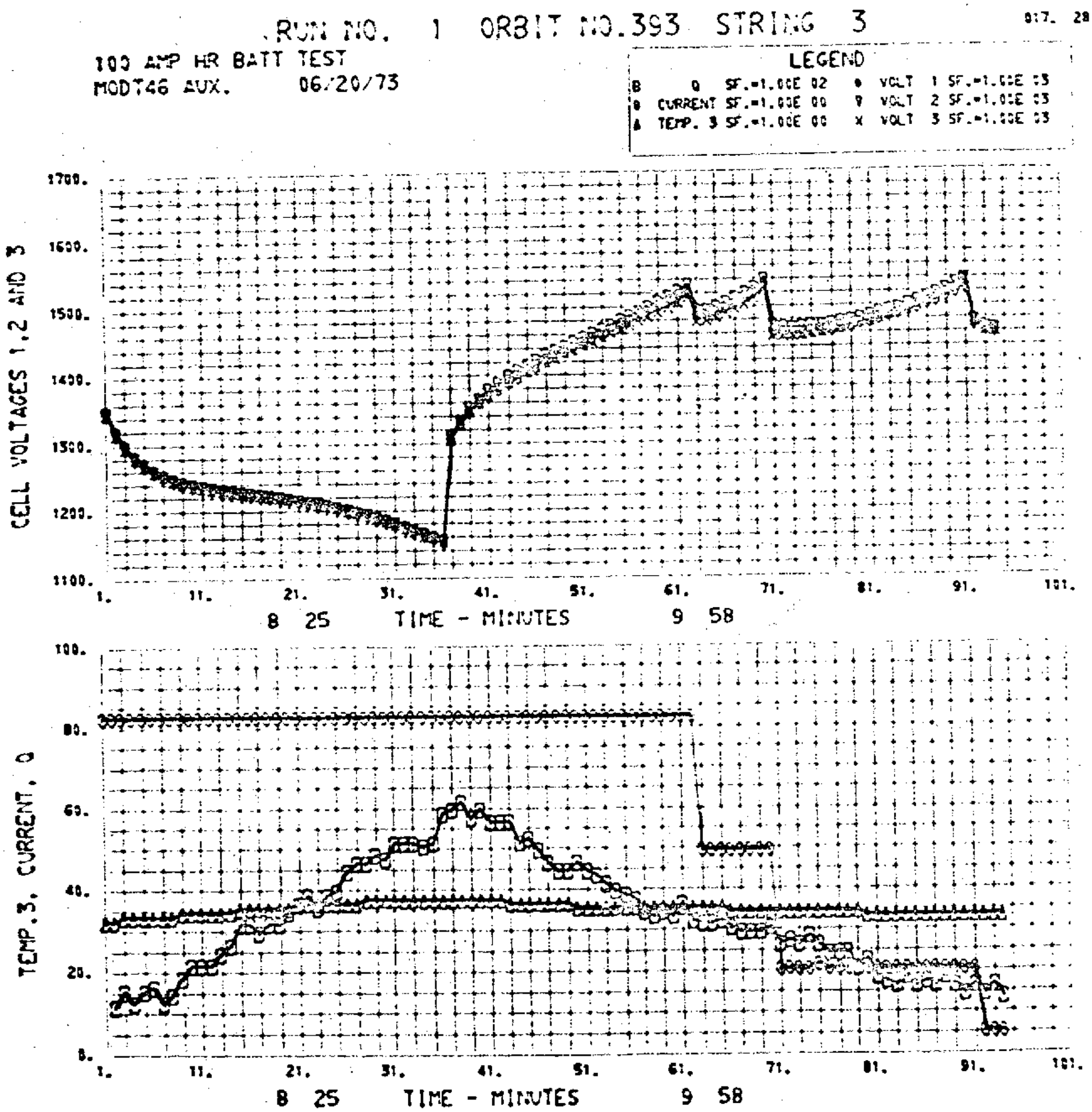


RUN NO. 1 ORBIT NO.393 STRING 1
017. 26
100 AMP HR BATT TEST
MODT46 AUX. 06/20/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58

RE-13


RUN NO. 1 ORBIT NO.393 STRING 2
100 AMP HR BATT TEST
MODT46 AUX. 06/20/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58

R-14

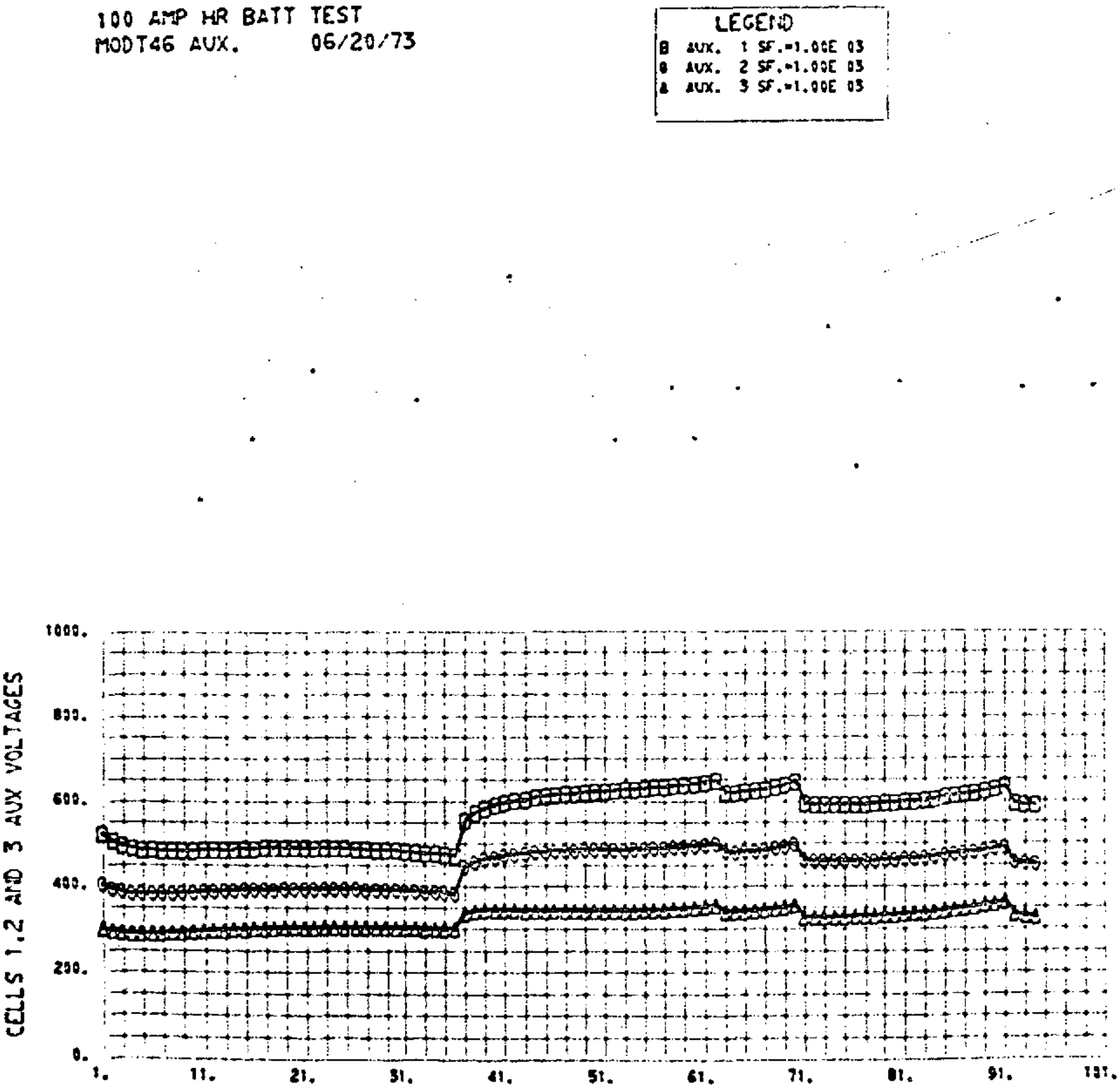

RUN NO. 1 ORBIT NO.393 STRING 3
017. 28
100 AMP HR BATT TEST
MODT46 AUX. 06/20/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58

R5-1J

RUN NO. 1 ORBIT NO.393 STRING 3

917. 29

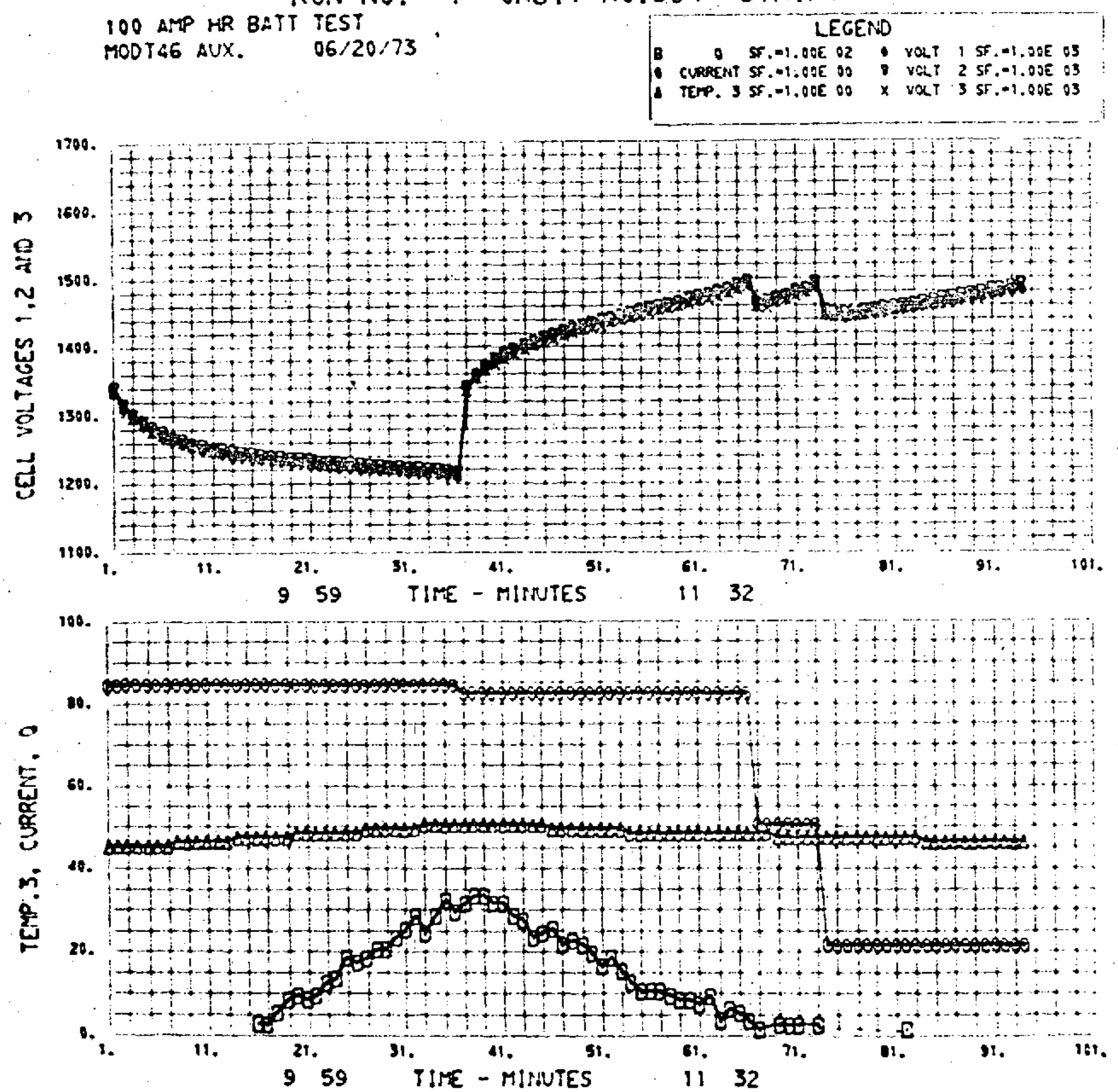
100 AMP HR BATT TEST
MODT46 AUX. 06/20/73



RS-16

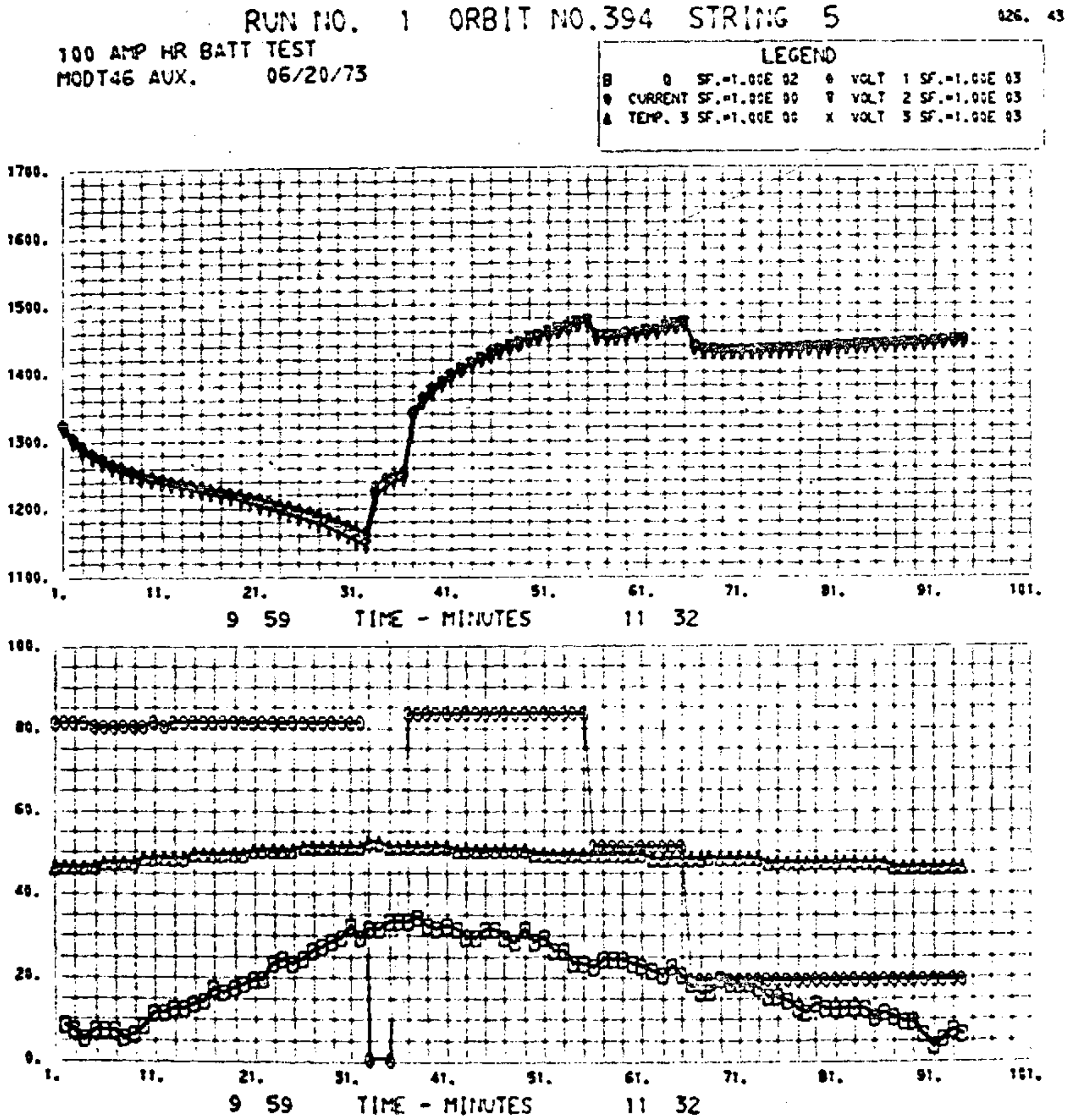
RUN NO. 1 ORBIT NO.394 STRING 4 026. 42

100 AMP HR BATT TEST
MODT46 AUX. 06/20/73



R5-17

RUN NO. 1 ORBIT NO.394 STRING 5



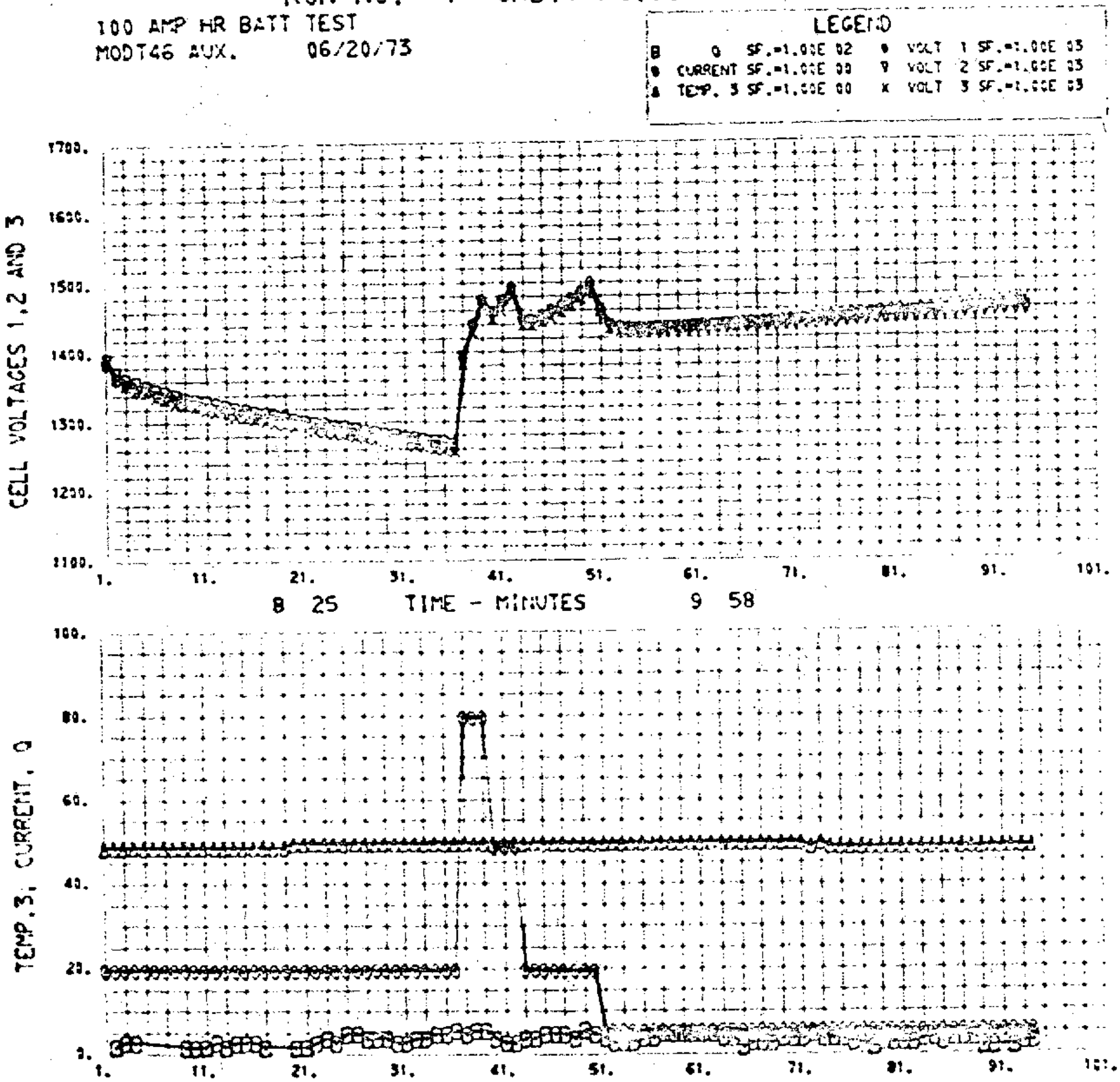
C-5

R5-18

RUN NO. 1 ORBIT NO.393 STRING 6

017. 32

100 AMP HR BATT TEST
MODT46 AUX. 06/20/73

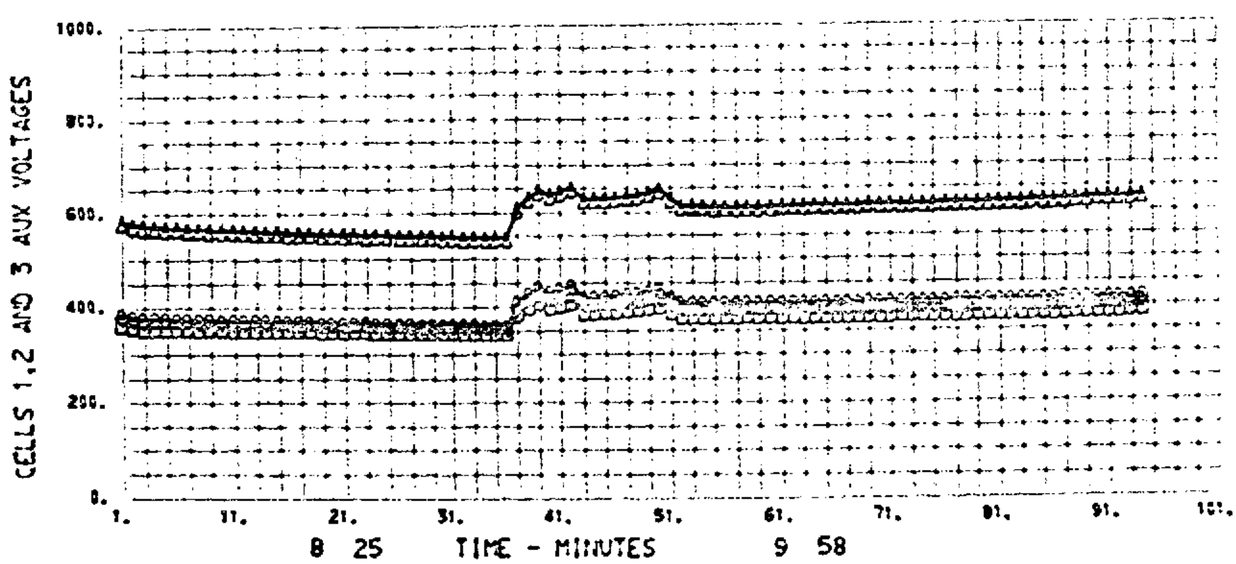


RS-19

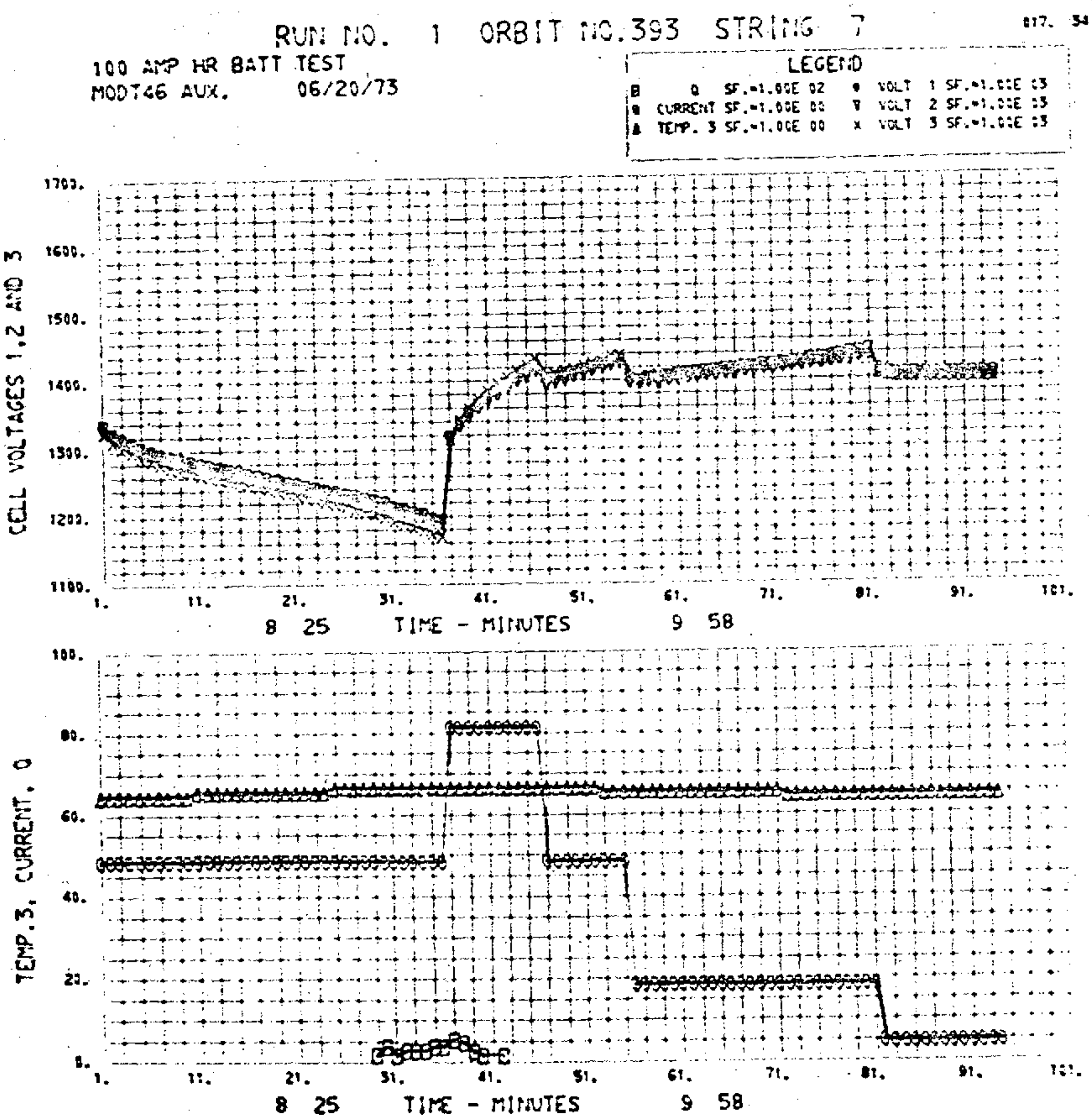
RUN NO. 1 ORBIT NO.393 STRING 6 017. 33

100 AMP HR BATT TEST
MODT46 AUX. 06/20/73

LEGEND
AUX. 1 SF.=1.00E 03
AUX. 2 SF.=1.00E 03
AUX. 3 SF.=1.00E 03



R5-20



RUN NO. 1 ORBIT NO.393 STRING 7
100 AMP HR BATT TEST
MODT46 AUX. 06/20/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58

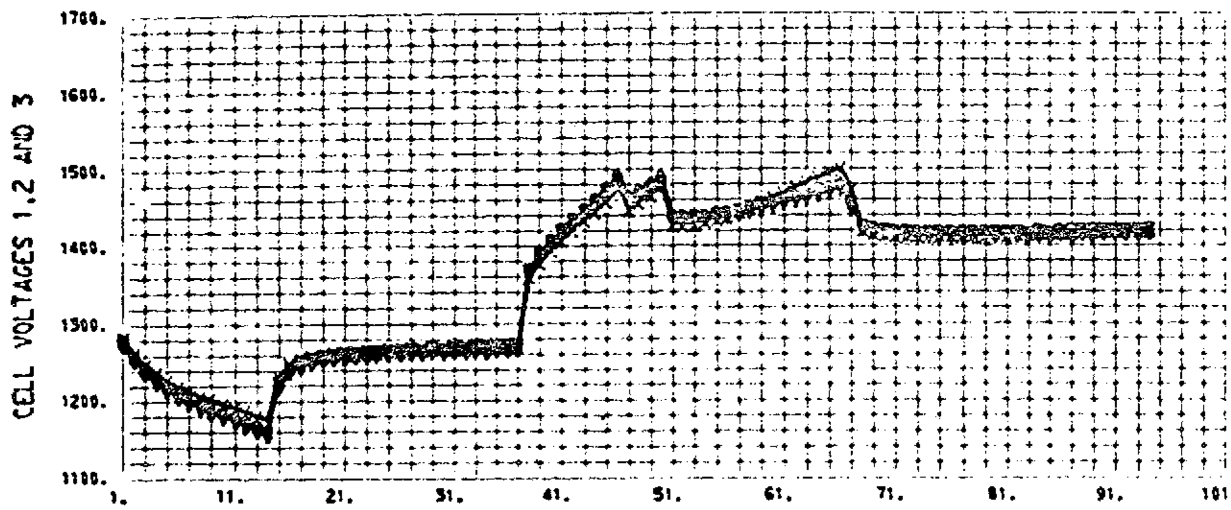
RE-21

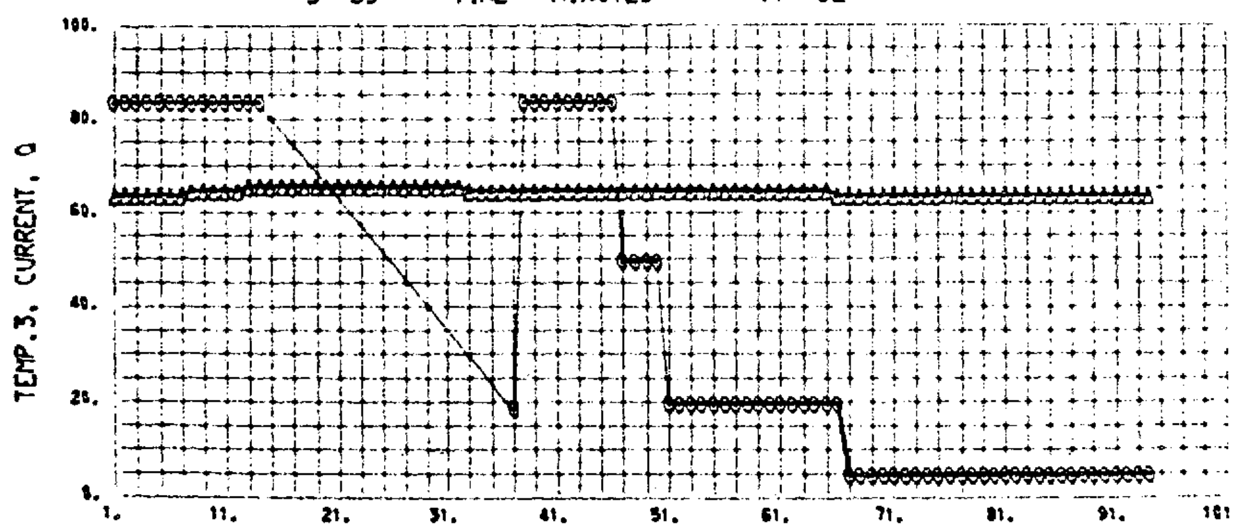
RUN NO. 1 ORBIT NO.394 STRING 8 026. 47

100 AMP HR BATT TEST
MODT46 AUX. 06/20/73

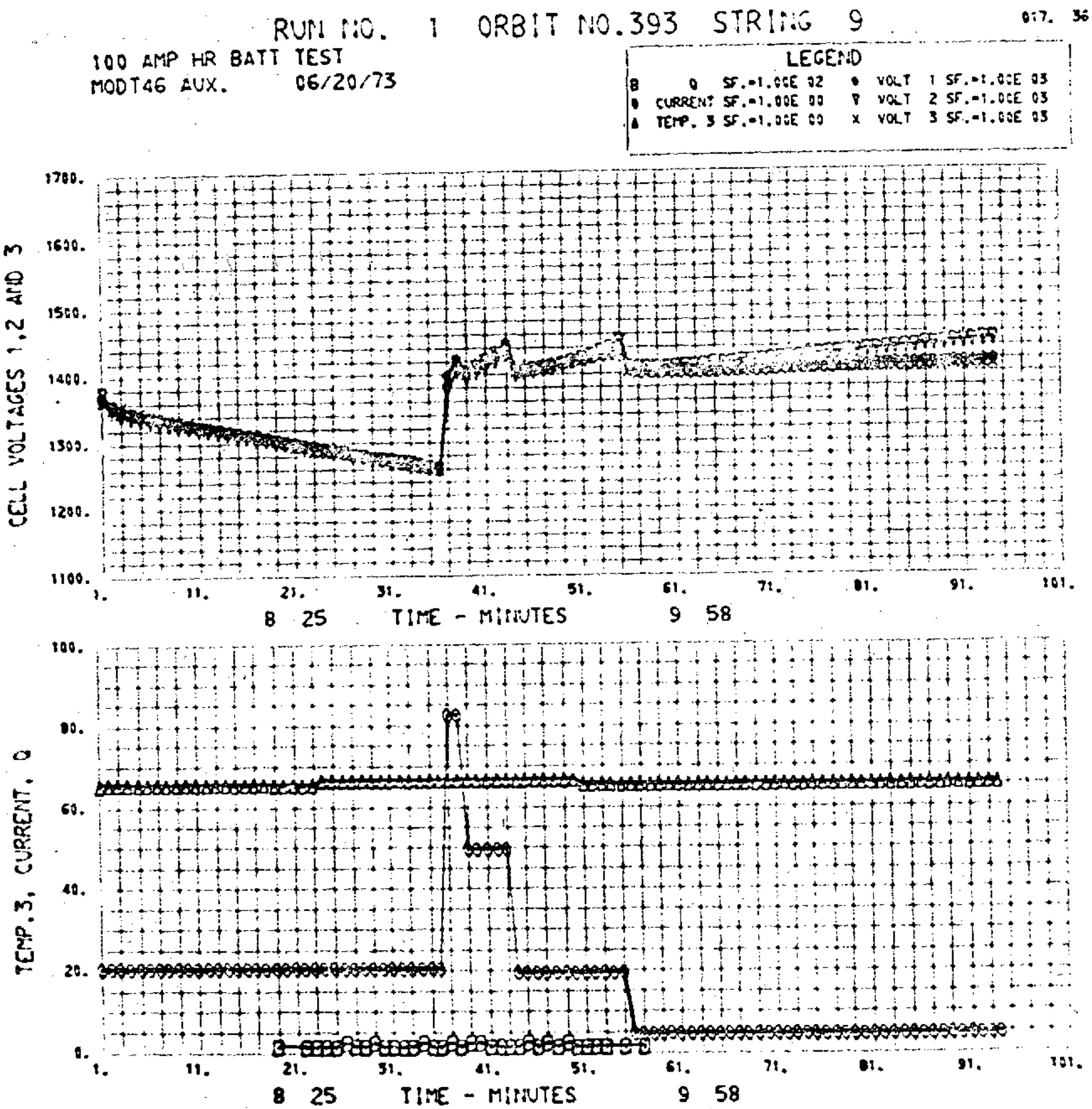
LEGEND

Q SF.=1.00E 02	VOLT 1 SF.=1.00E 03
CURRENT SF.=1.00E 00	VOLT 2 SF.=1.00E 03
TEMP. 3 SF.=1.00E 00	X VOLT 3 SF.=1.00E 03





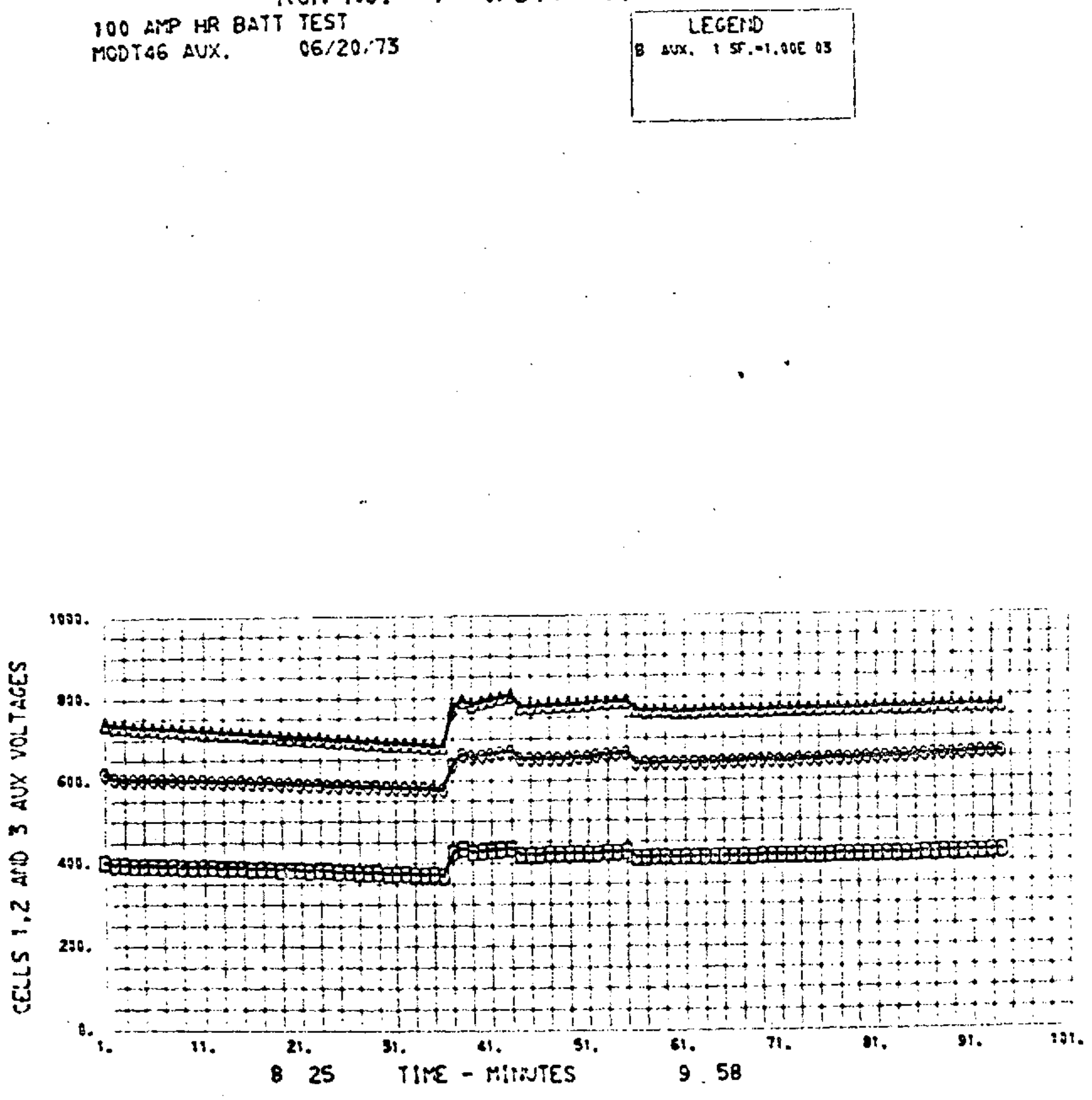
R5-22


RUN NO. 1 ORBIT NO.393 STRING 9
017. 36
100 AMP HR BATT TEST
MODT46 AUX. 06/20/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
8 25 TIME - MINUTES 9 58

RE-23

RUN NO. 1 ORBIT NO.393 STRING 9

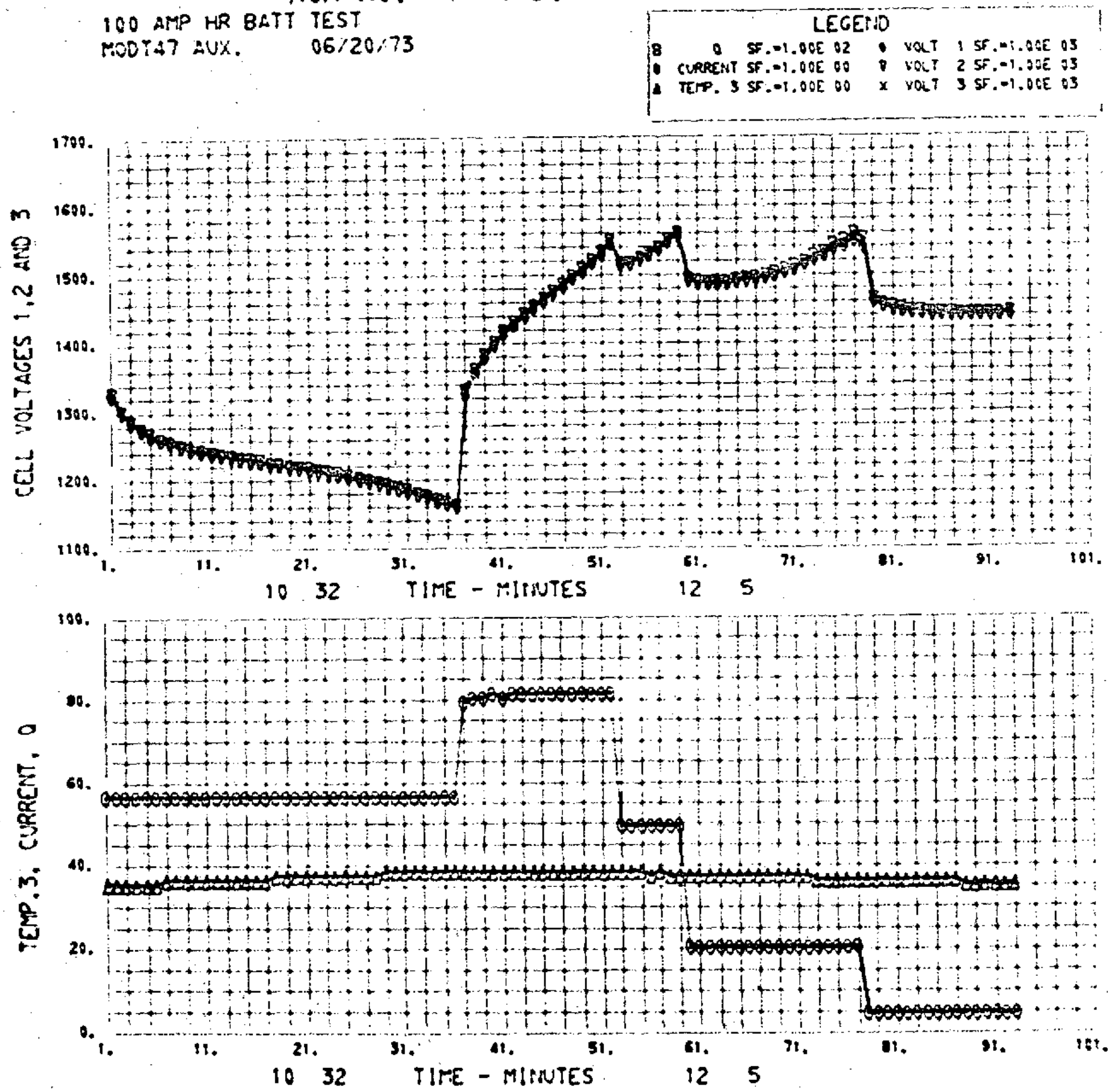
100 AMP HR BATT TEST
MODT46 AUX. 06/20/73



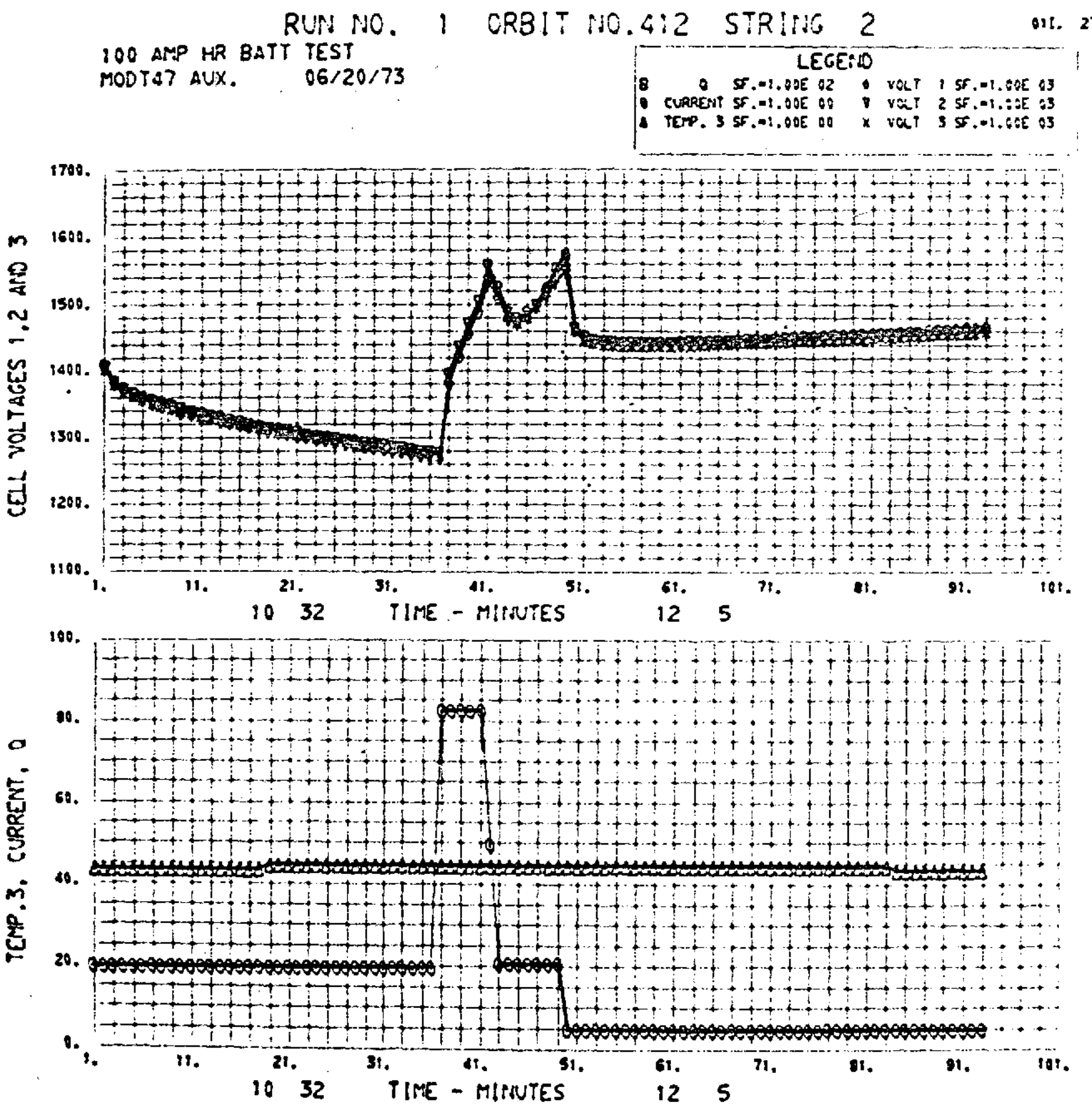
RB-24

RUN NO. 1 ORBIT NO. 412 STRING 1

100 AMP HR BATT TEST
MODT47 AUX. 06/20/73

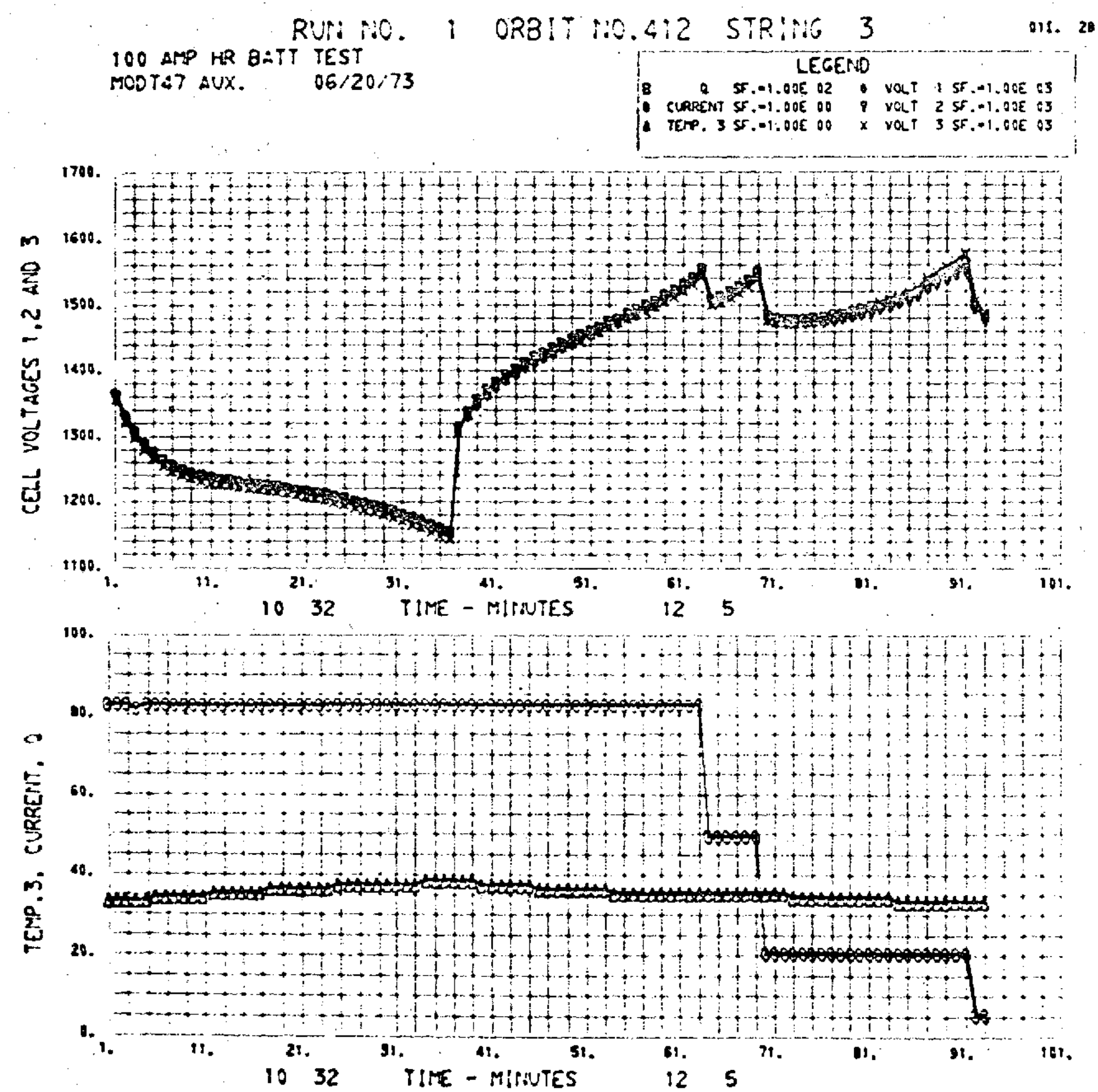


RS-25



RUN NO. 1 ORBIT NO.412 STRING 2
100 AMP HR BATT TEST
MODT47 AUX. 06/20/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
10 32 TIME - MINUTES 12 5
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
10 32 TIME - MINUTES 12 5

RE-26

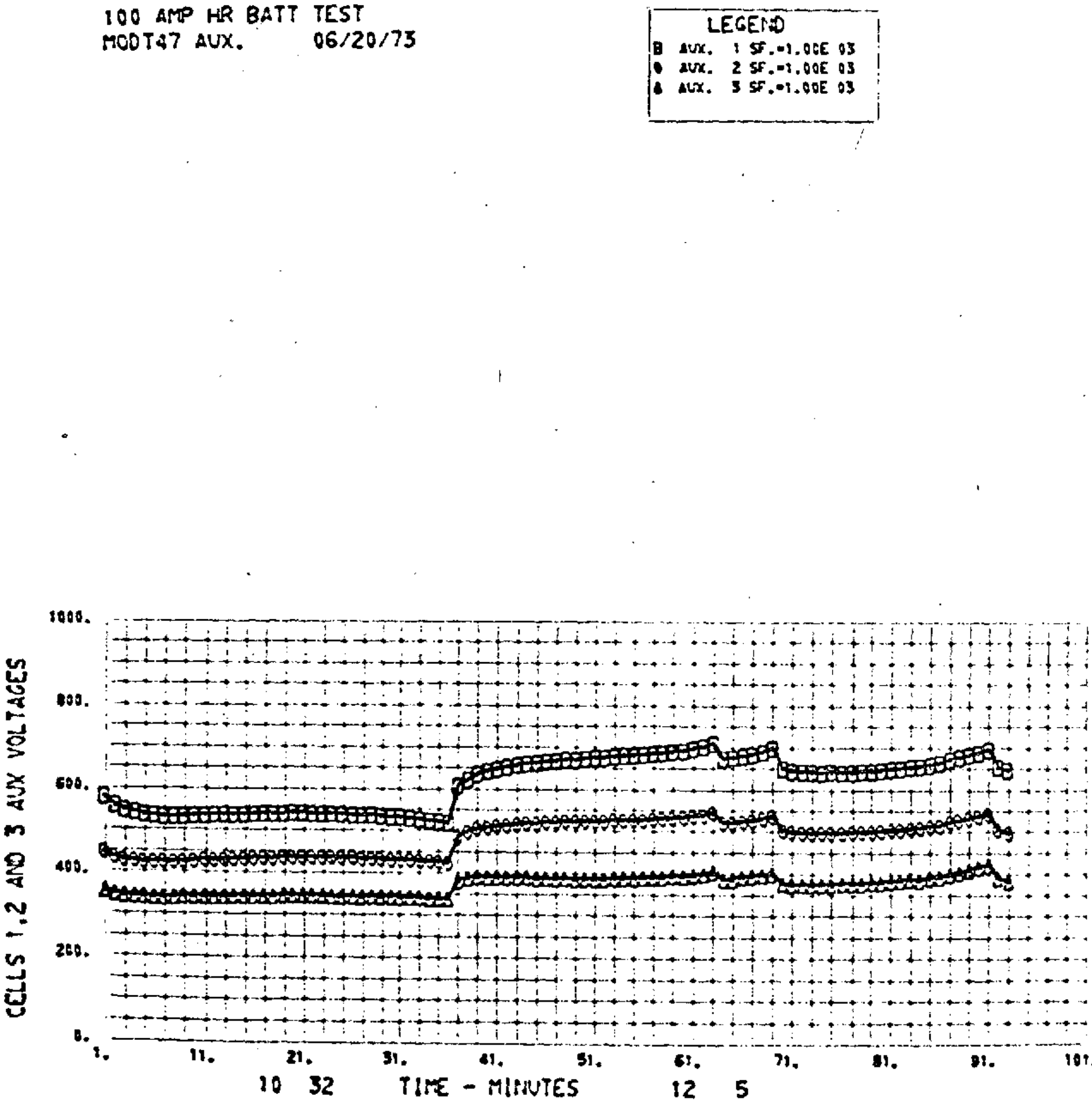

RUN NO. 1 ORBIT NO.412 STRING 3
100 AMP HR BATT TEST
MODT47 AUX. 06/20/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
10 32 TIME - MINUTES 12 5
TEMP.3, CURRENT, Q
10 32 TIME - MINUTES 12 5

RS-27

RUN NO. 1 ORBIT NO.412 STRING 3

FIG. 29

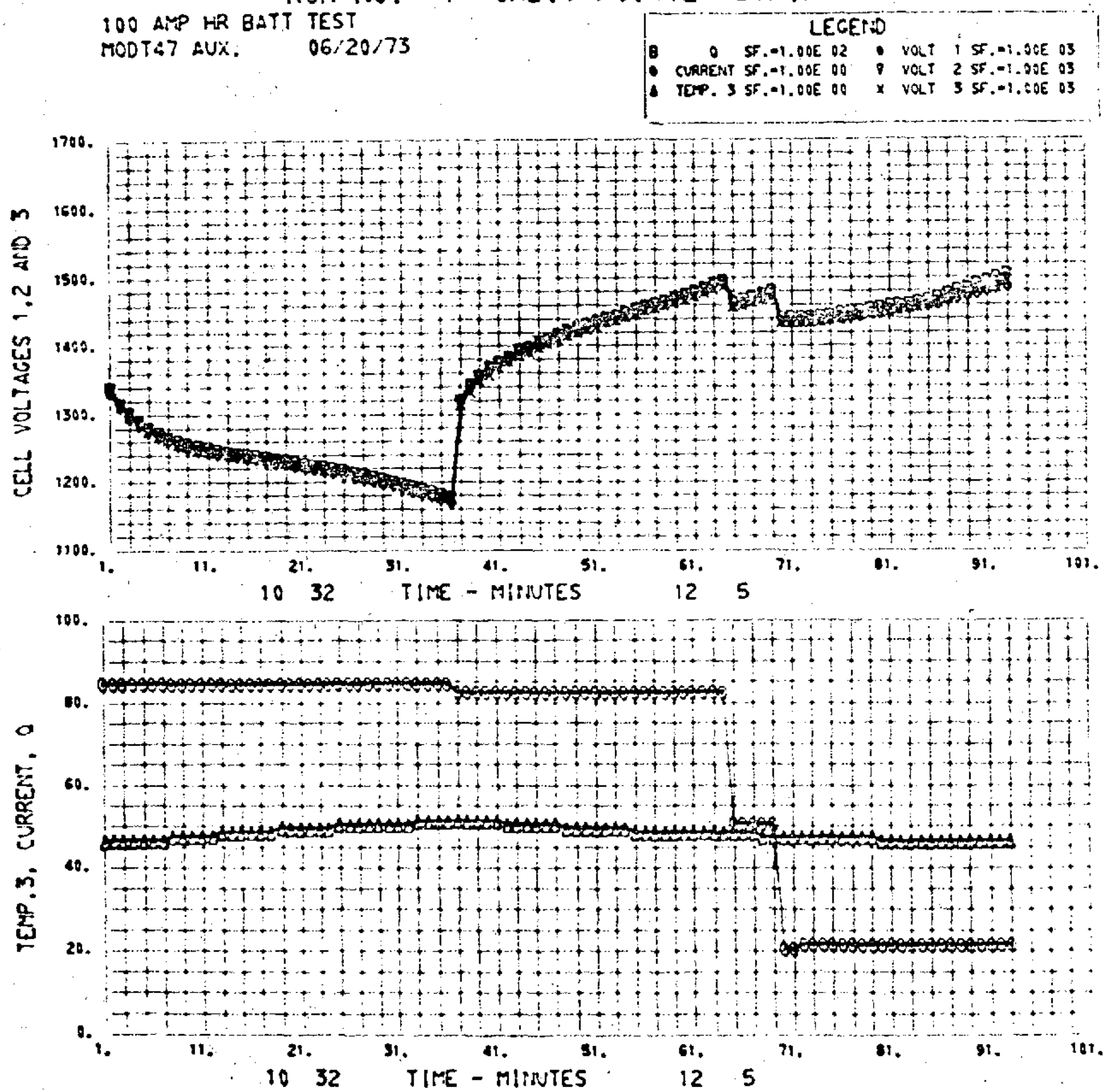
100 AMP HR BATT TEST
MODT47 AUX. 06/20/73



RE-18

RUN NO. 1 ORBIT NO.412 STRING 4 OIT. 30

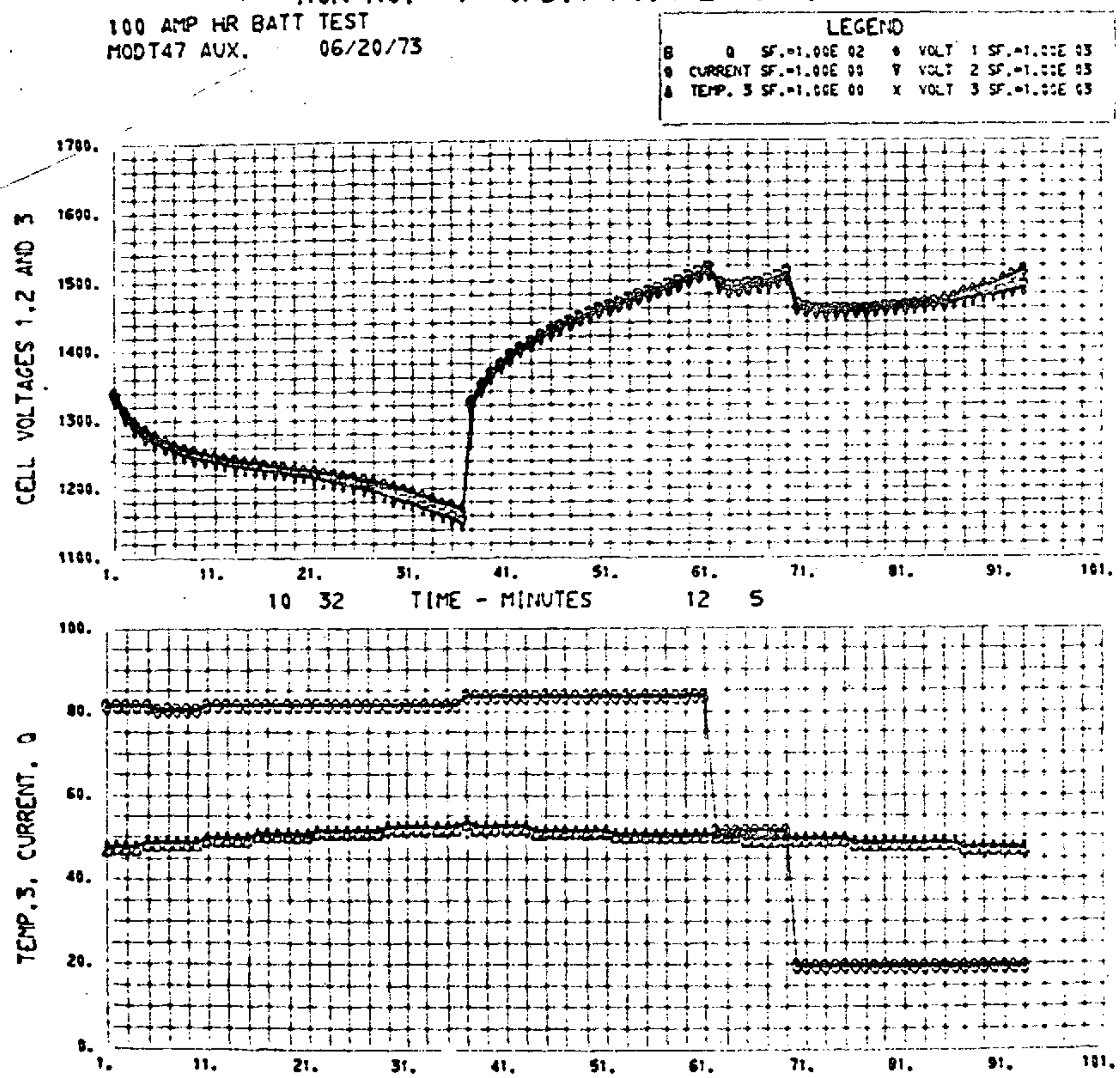
100 AMP HR BATT TEST
MODT47 AUX. 06/20/73



R5-29

RUN NO. 1 ORBIT NO.412 STRING 5

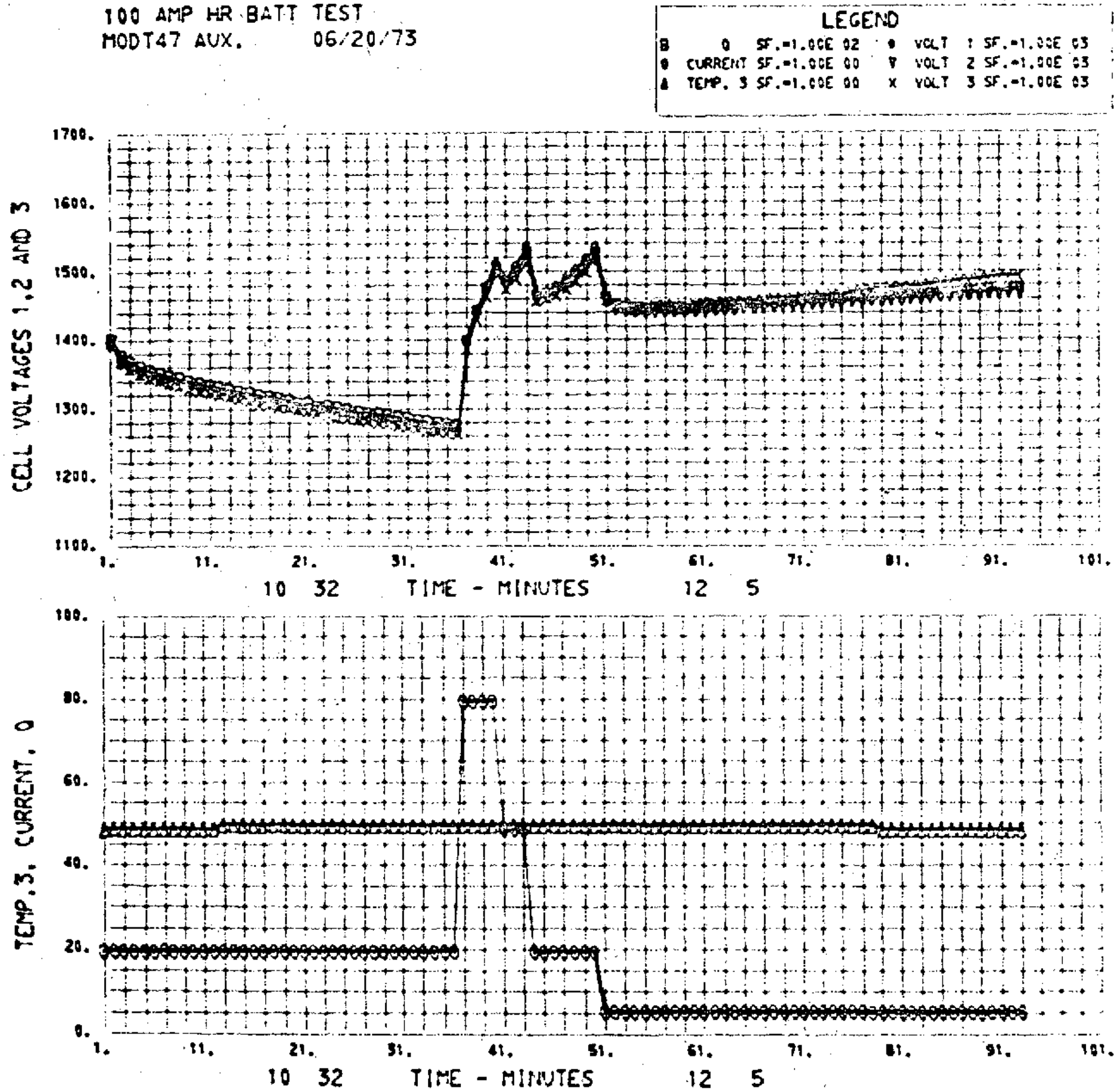
100 AMP HR BATT TEST
MODT47 AUX. 06/20/73



R-30

RUN NO. 1 ORBIT NO.412 STRING 6

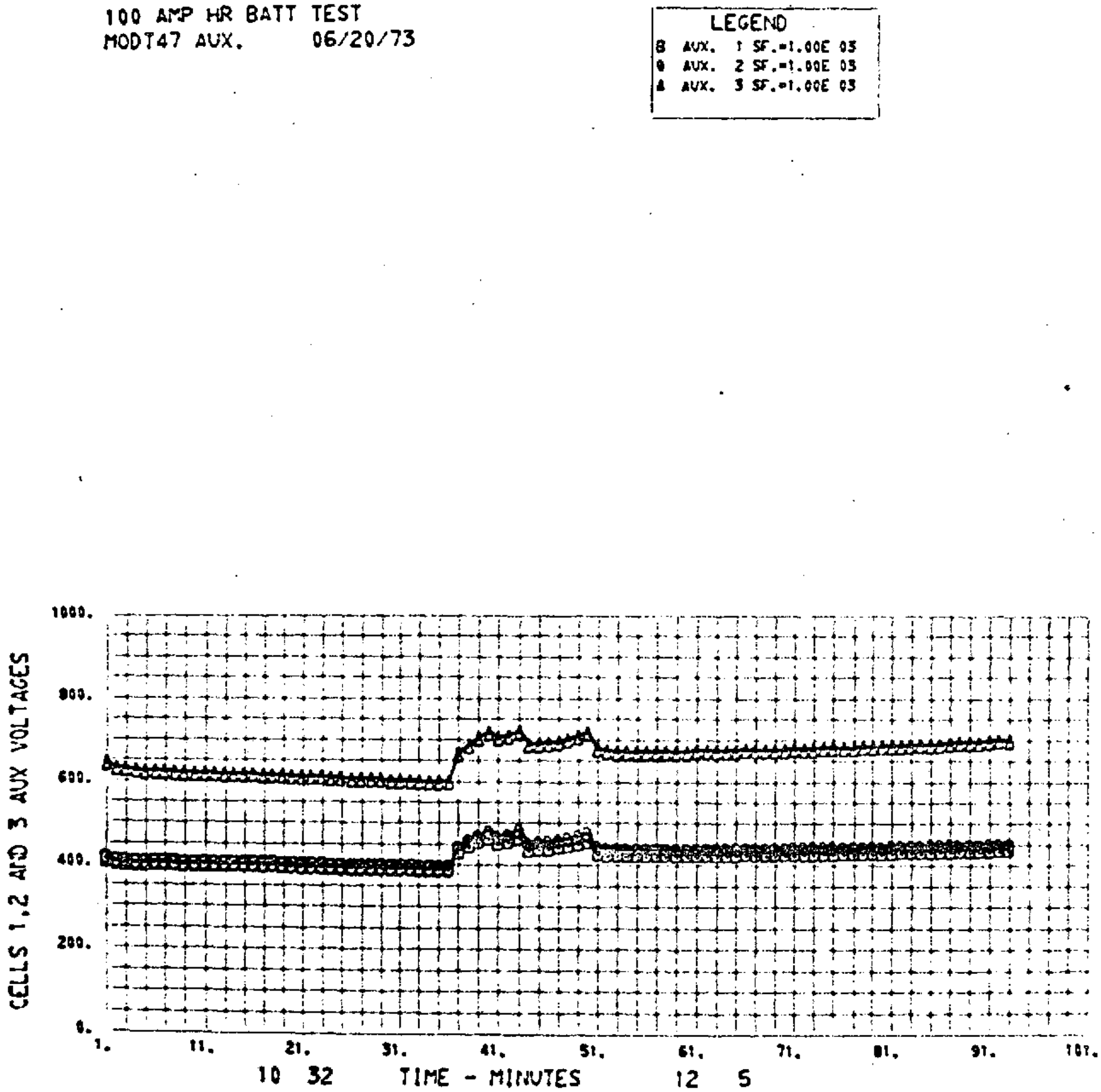
100 AMP HR BATT TEST
MODT47 AUX. 06/20/73



R5-31

RUN NO. 1 ORBIT NO.412 STRING 6 011. 33

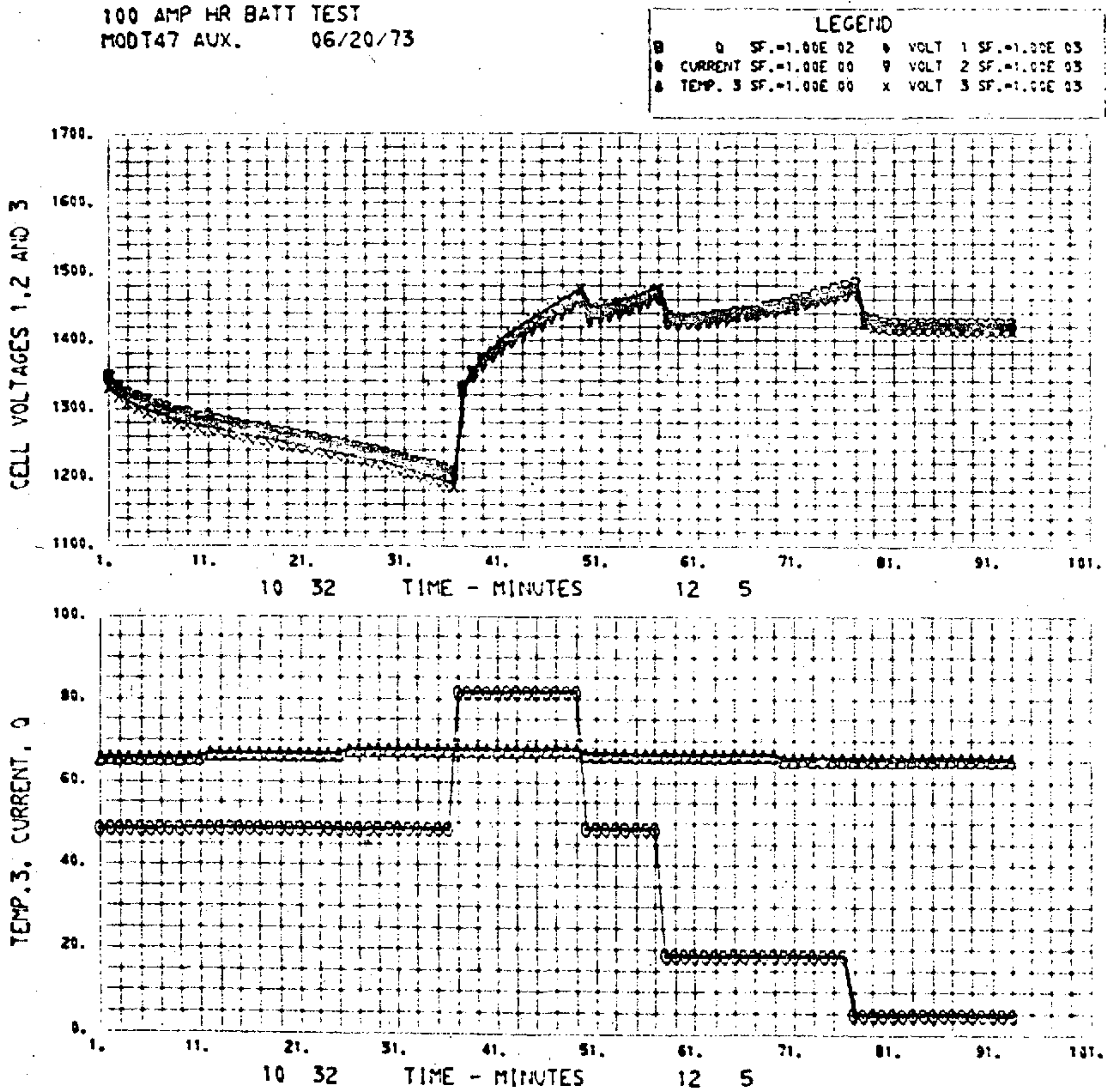
100 AMP HR BATT TEST
MODT47 AUX. 06/20/73



RF-22.

RUN NO. 1 ORBIT NO.412 STRING 7

100 AMP HR BATT TEST
MODT47 AUX. 06/20/73

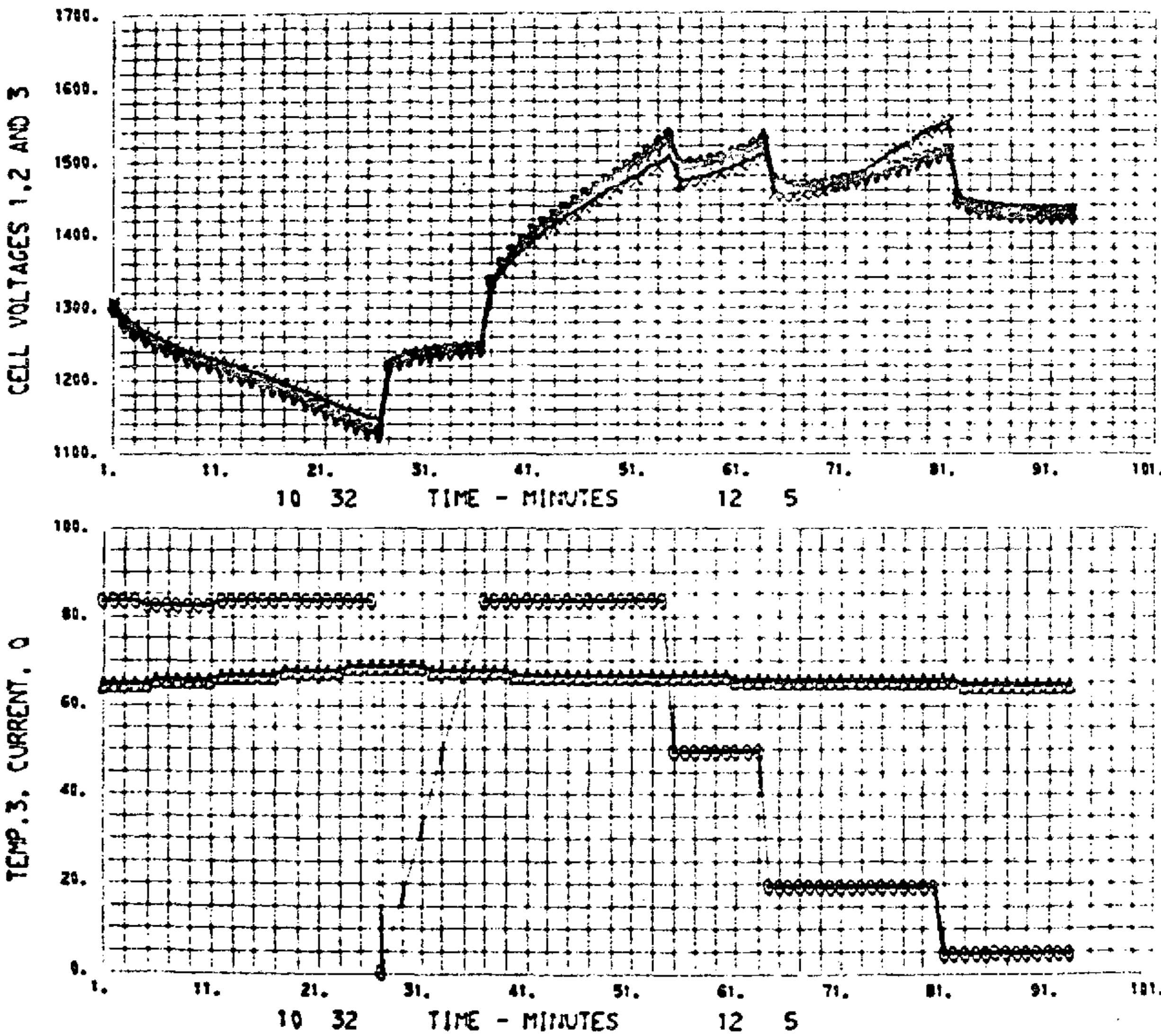


R4F-33

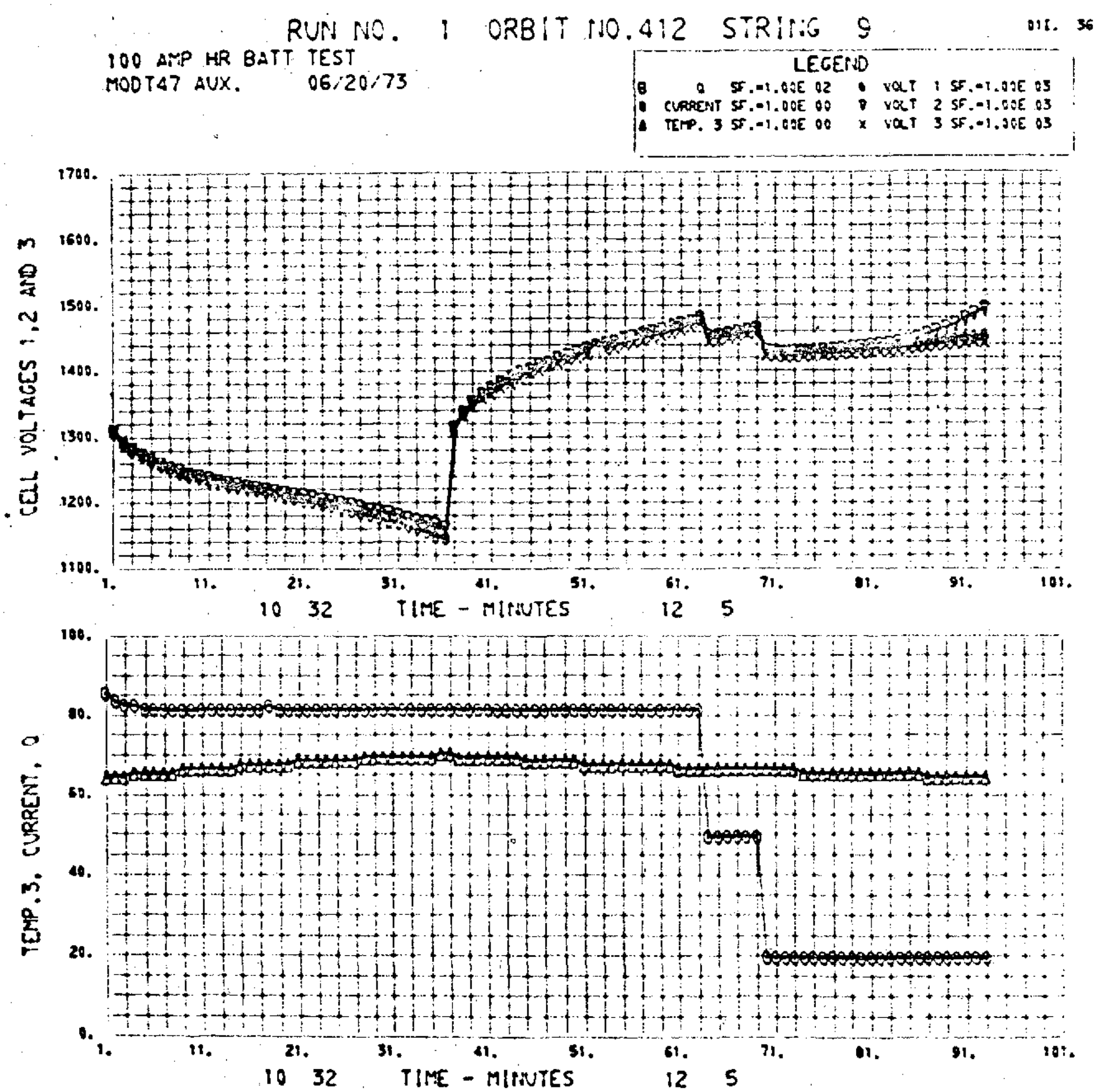
RUN NO. 1 ORBIT NO.412 STRING 8

100 AMP HR BATT TEST
MODT47 AUX. 06/20/73

LEGEND			
Q	SF.=1.00E 02	VOLT 1	SF.=1.00E 03
CURRENT	SF.=1.00E 00	VOLT 2	SF.=1.00E 03
TEMP. 3	SF.=1.00E 00	VOLT 3	SF.=1.00E 03



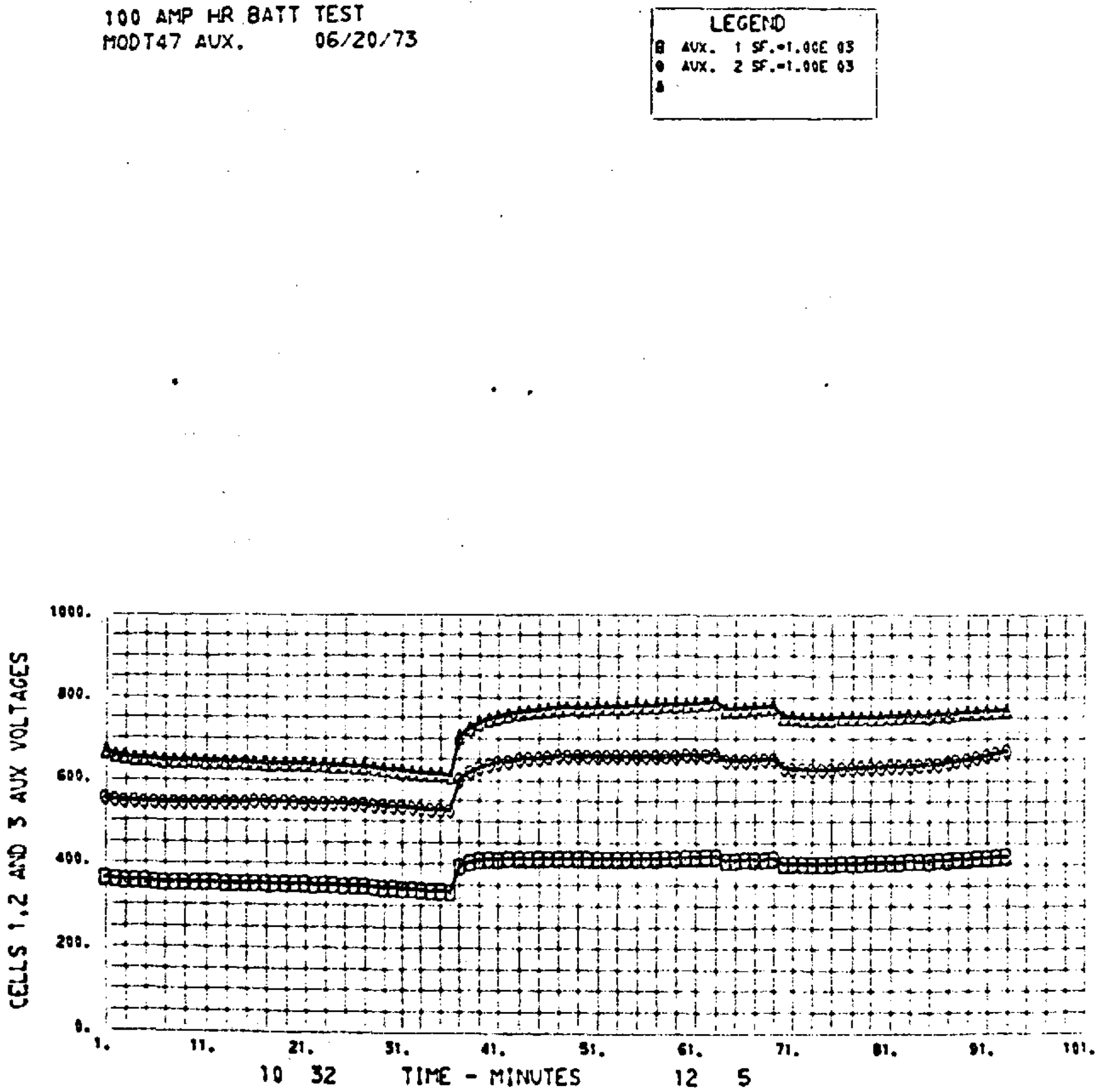
QS-34


RUN NO. 1 ORBIT NO.412 STRING 9
100 AMP HR BATT TEST
MODT47 AUX. 06/20/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
TIME - MINUTES
10 32
12 5
TEMP.3, CURRENT, Q

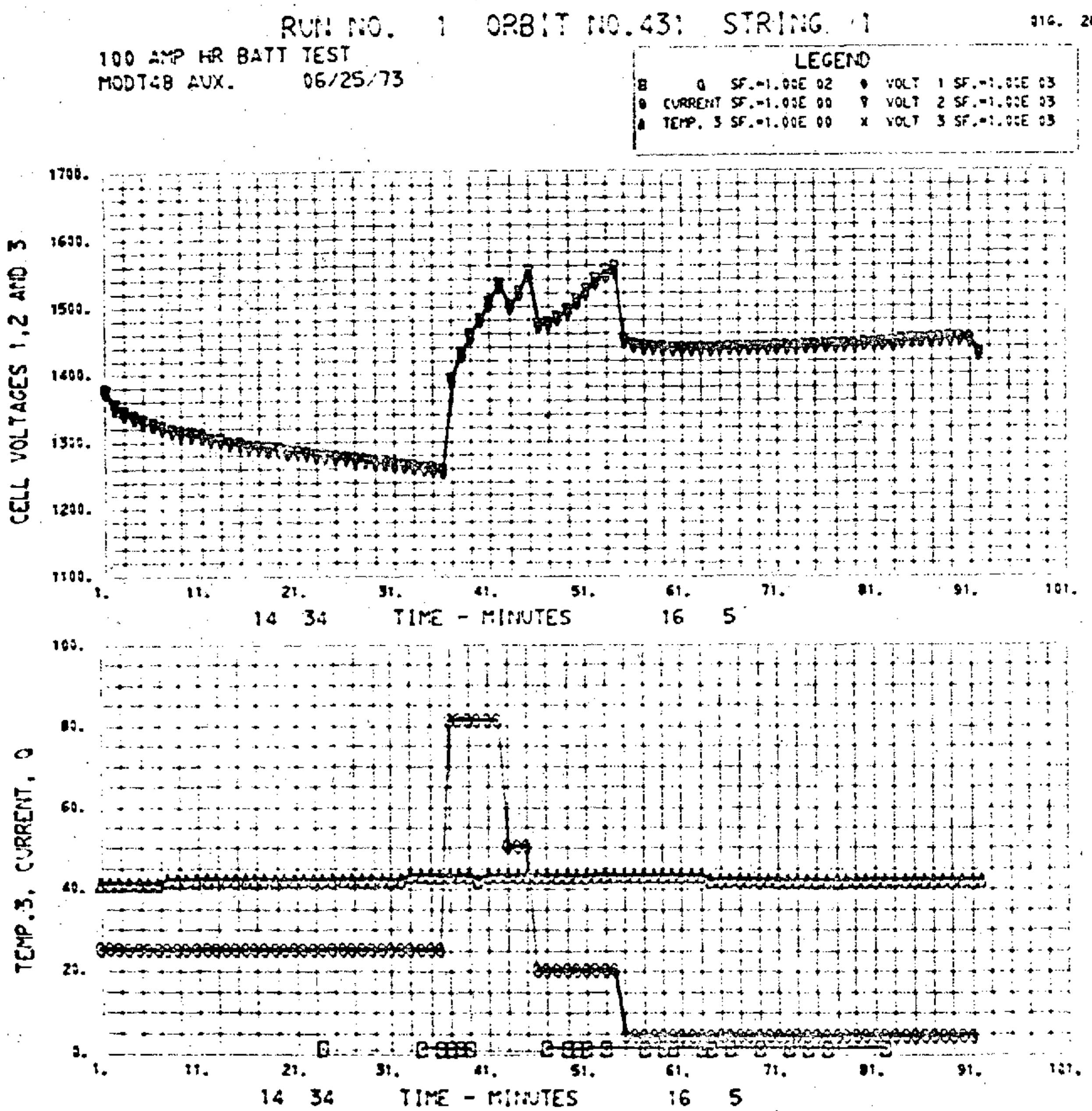
R5-35

RUN NO. 1 ORBIT NO.412 STRING 9

100 AMP HR BATT TEST
MODT47 AUX. 06/20/73

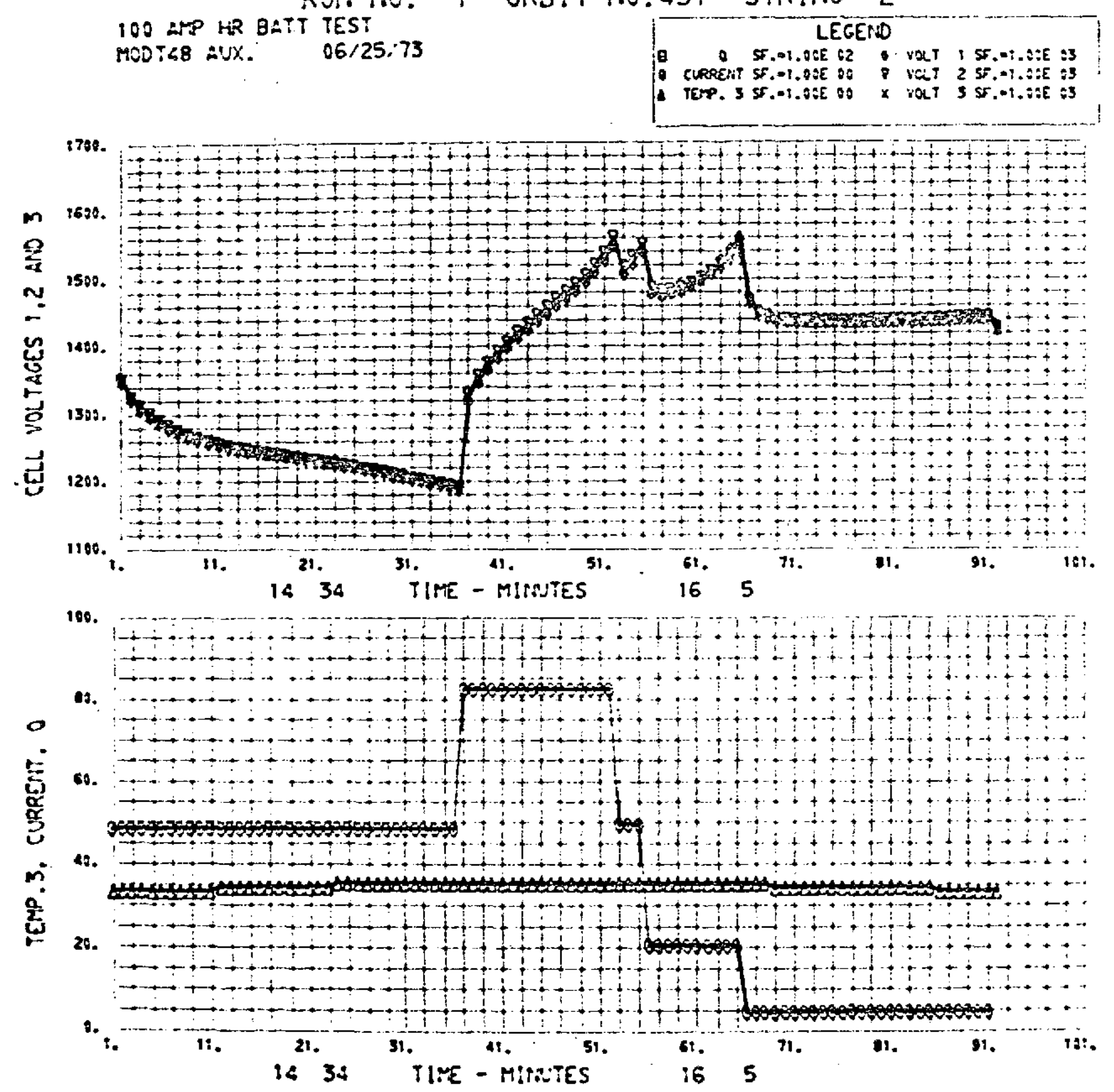


R-36


RUN NO. 1 ORBIT NO.431 STRING 1
100 AMP HR BATT TEST
MODT48 AUX. 06/25/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
14 34 TIME - MINUTES 16 5
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
14 34 TIME - MINUTES 16 5

R6-37

RUN NO. 1 ORBIT NO.431 STRING 2



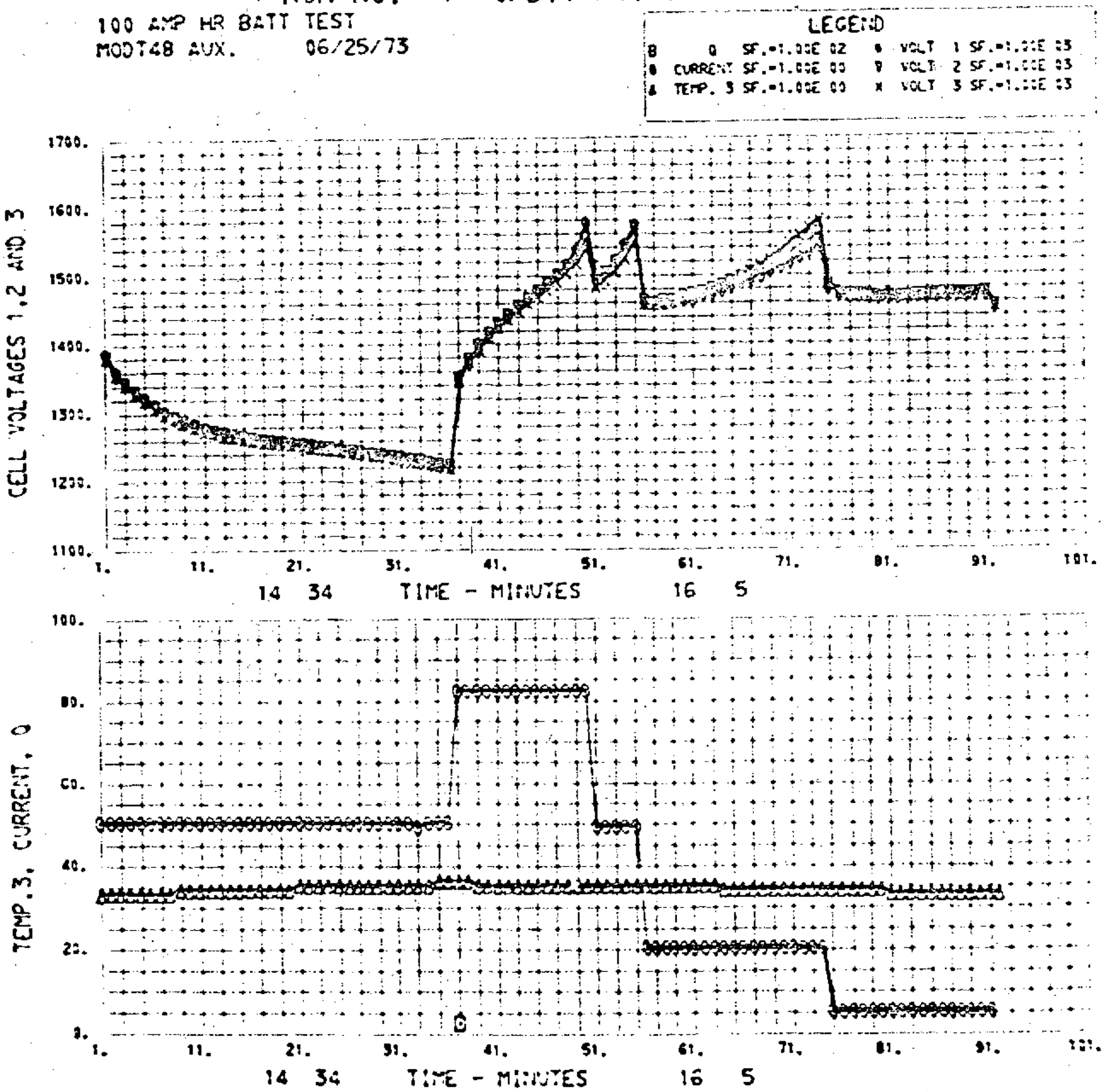
R5-38

RUN NO. 1 ORBIT NO.431 STRING 3

FIG. 28

100 AMP HR BATT TEST

MODT48 AUX. 06/25/73

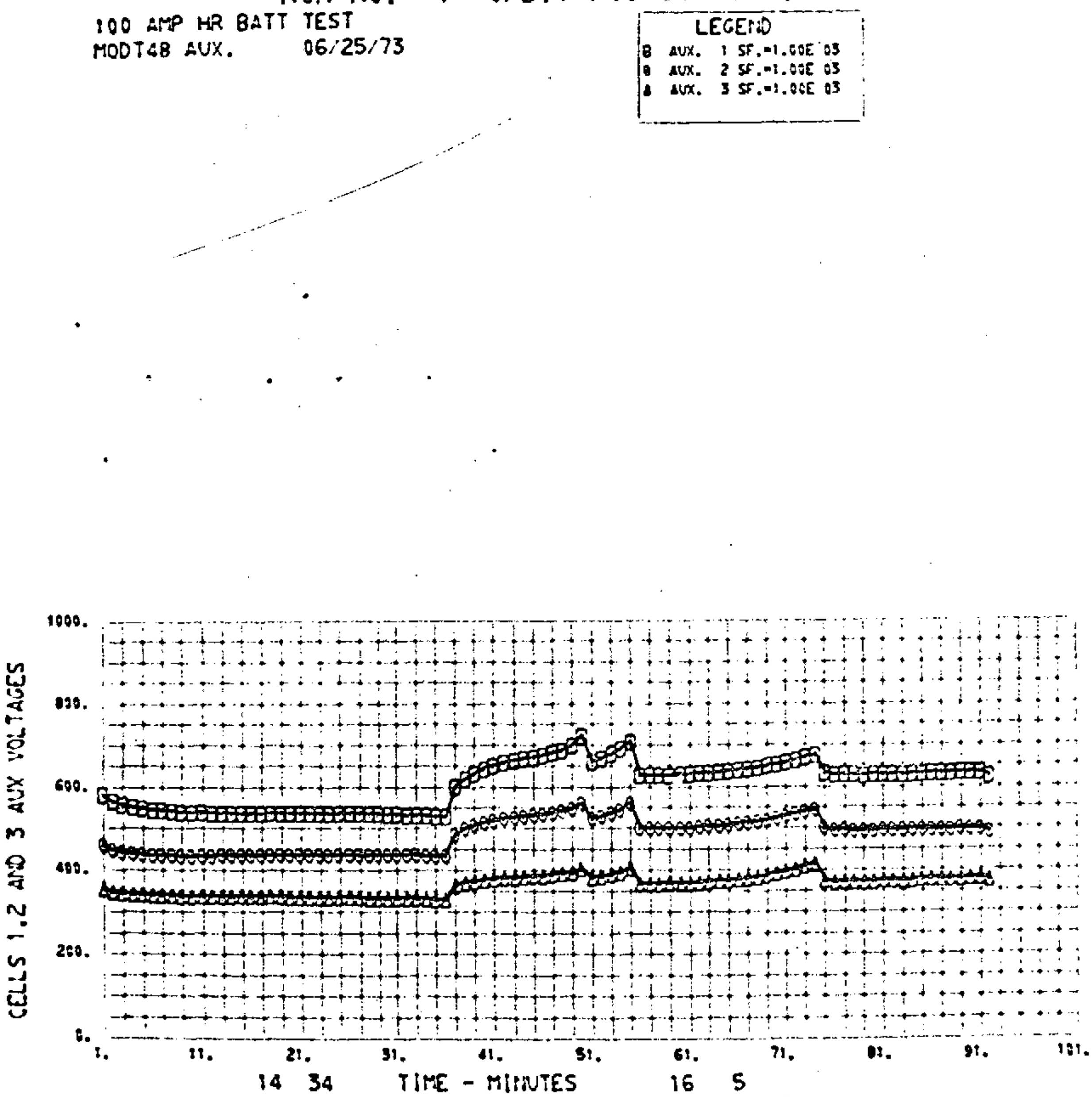


R5-39

RUN NO. 1 ORBIT NO.431 STRING 3

FIG. 29

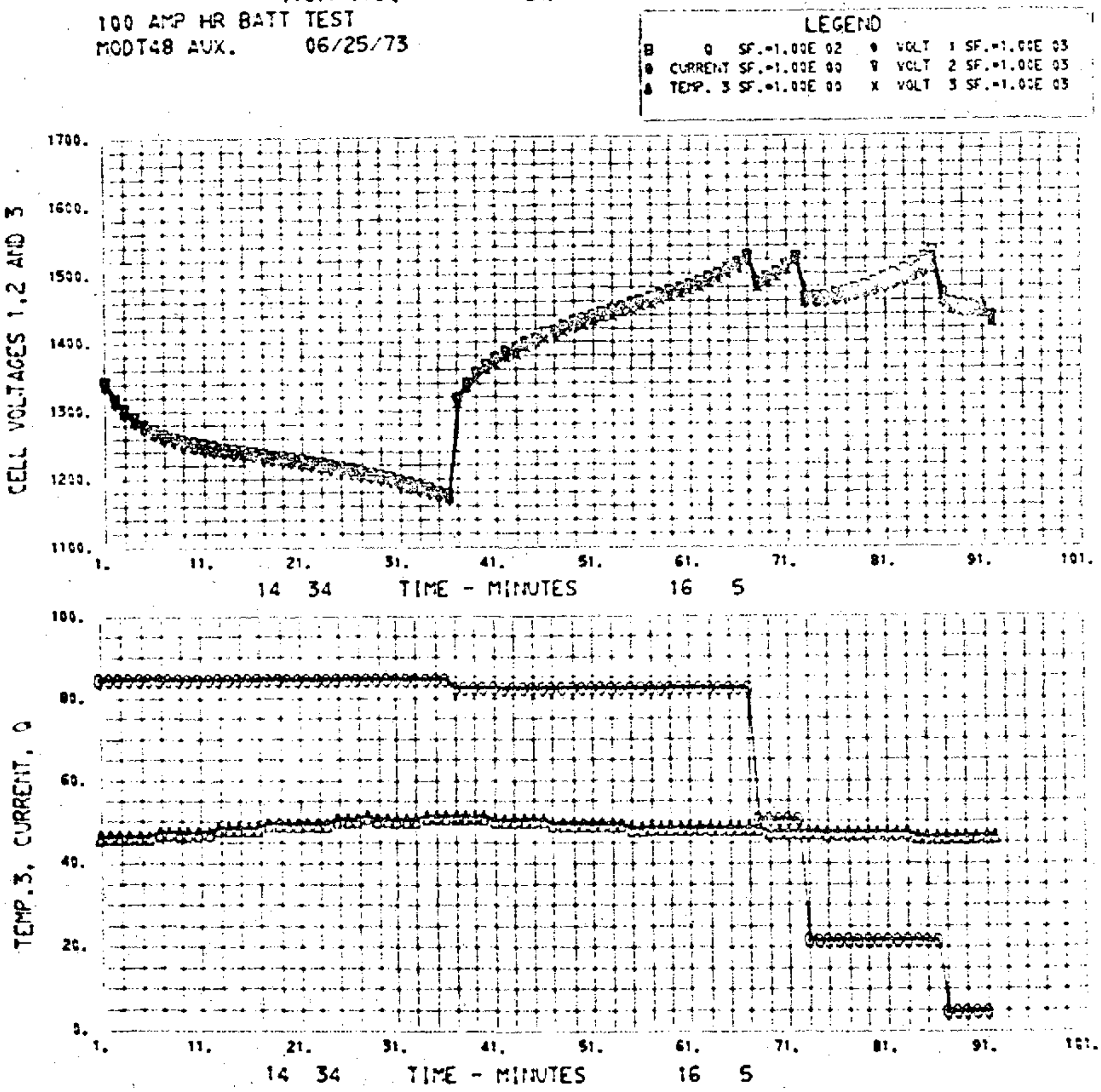
100 AMP HR BATT TEST
MODT4B AUX. 06/25/73



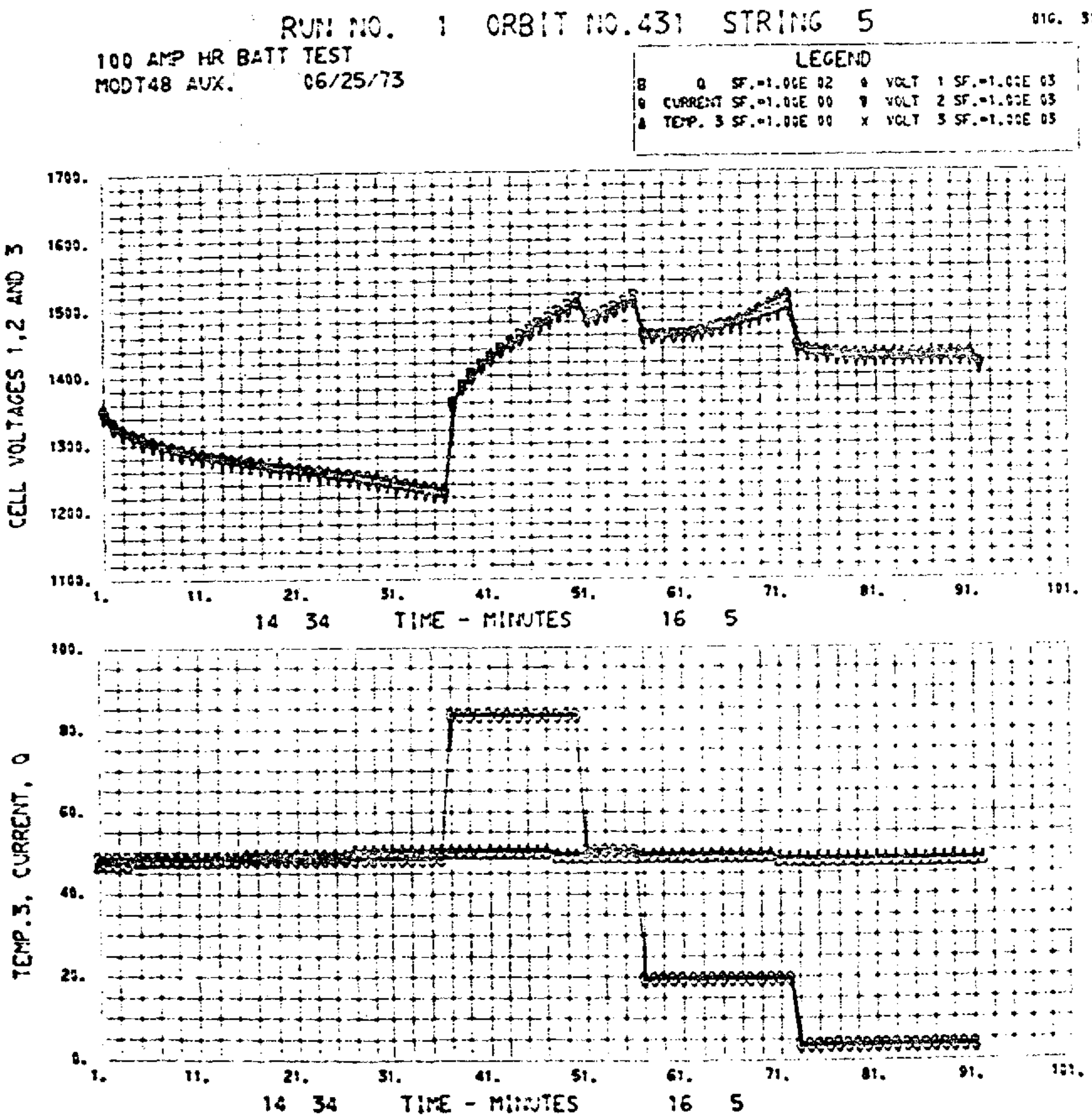
R5-40

RUN NO. 1 ORBIT NO.431 STRING 4

100 AMP HR BATT TEST
MODT48 AUX. 06/25/73



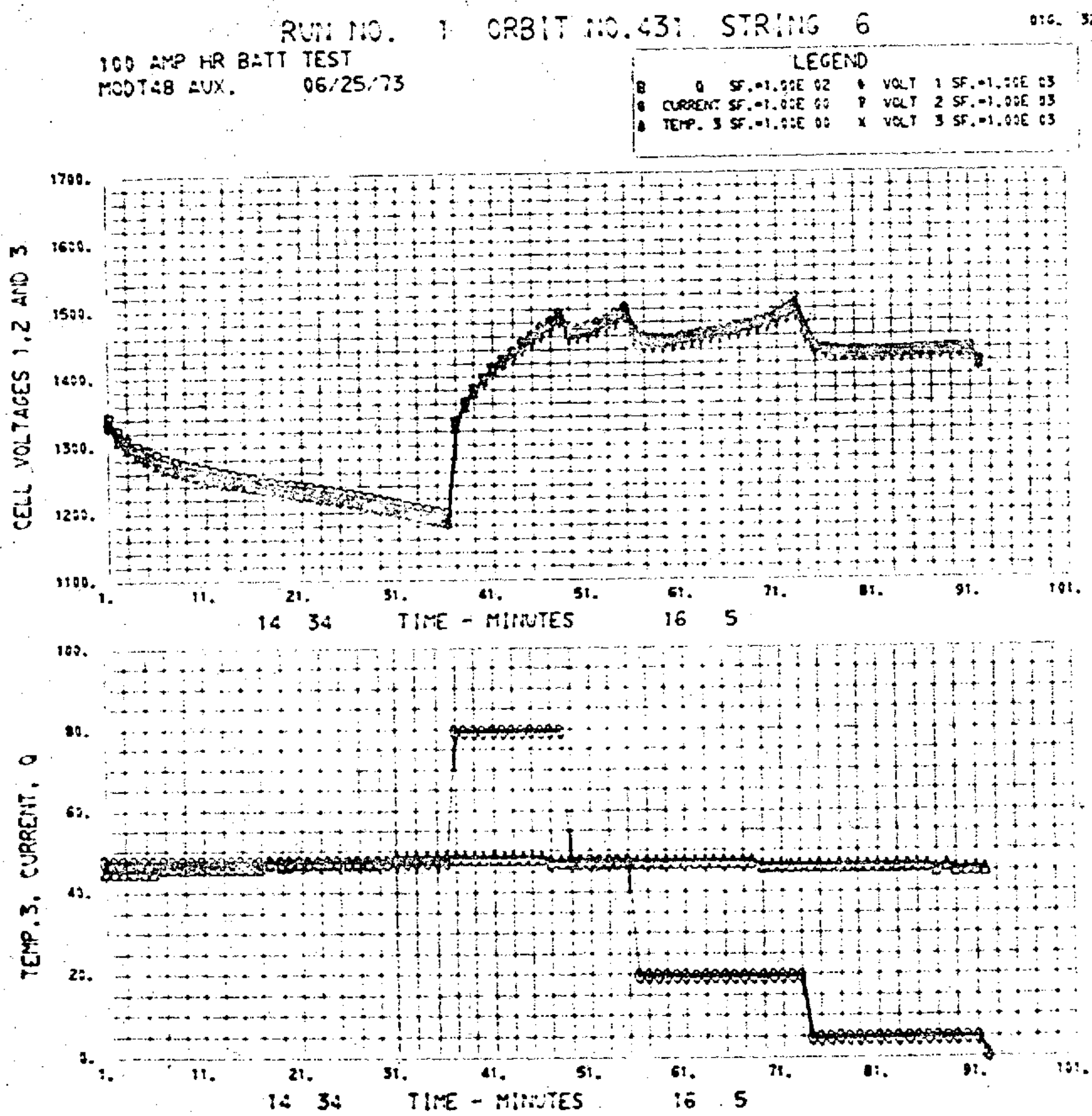
R5-41


RUN NO. 1 ORBIT NO.431 STRING 5
100 AMP HR BATT TEST
MODT48 AUX. 06/25/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
TIME - MINUTES
TEMP.3, CURRENT, Q
TIME - MINUTES

RS-42

RUN NO. 1 ORBIT NO.431 STRING 6

100 AMP HR BATT TEST
MODT48 AUX. 06/25/73

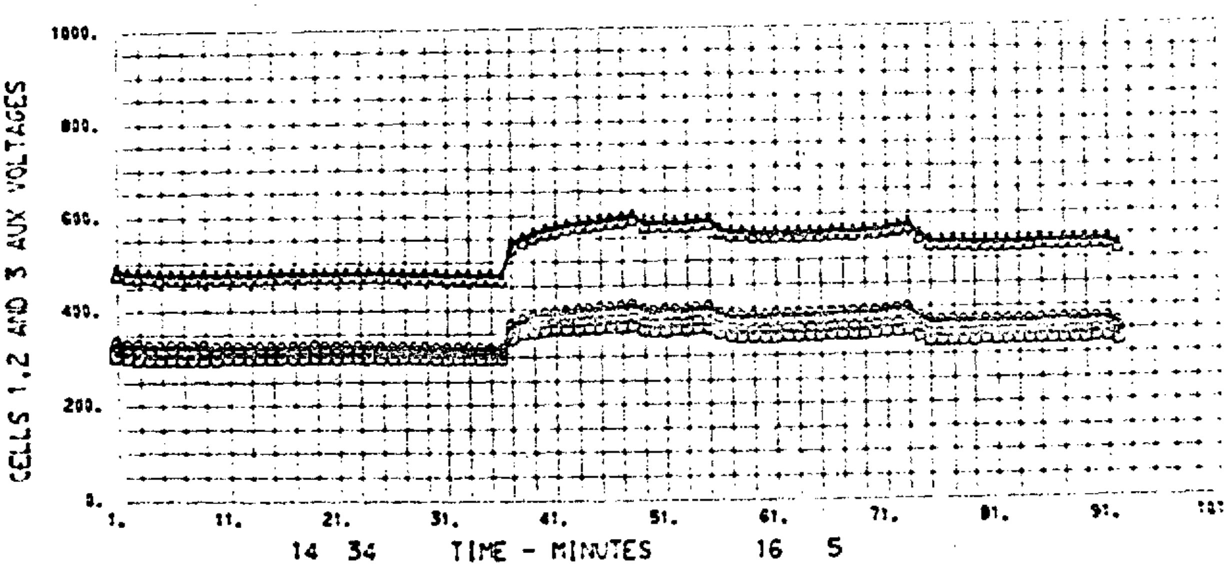


R5-43

RUN NO. 1 ORBIT NO.431 STRING 6 FIG. 33

100 AMP HR BATT TEST
MODT48 AUX. 06/25/73

LEGEND
B AUX. 1 SF.=1.00E 03
9 AUX. 2 SF.=1.00E 03
A AUX. 3 SF.=1.00E 03



R 5-41

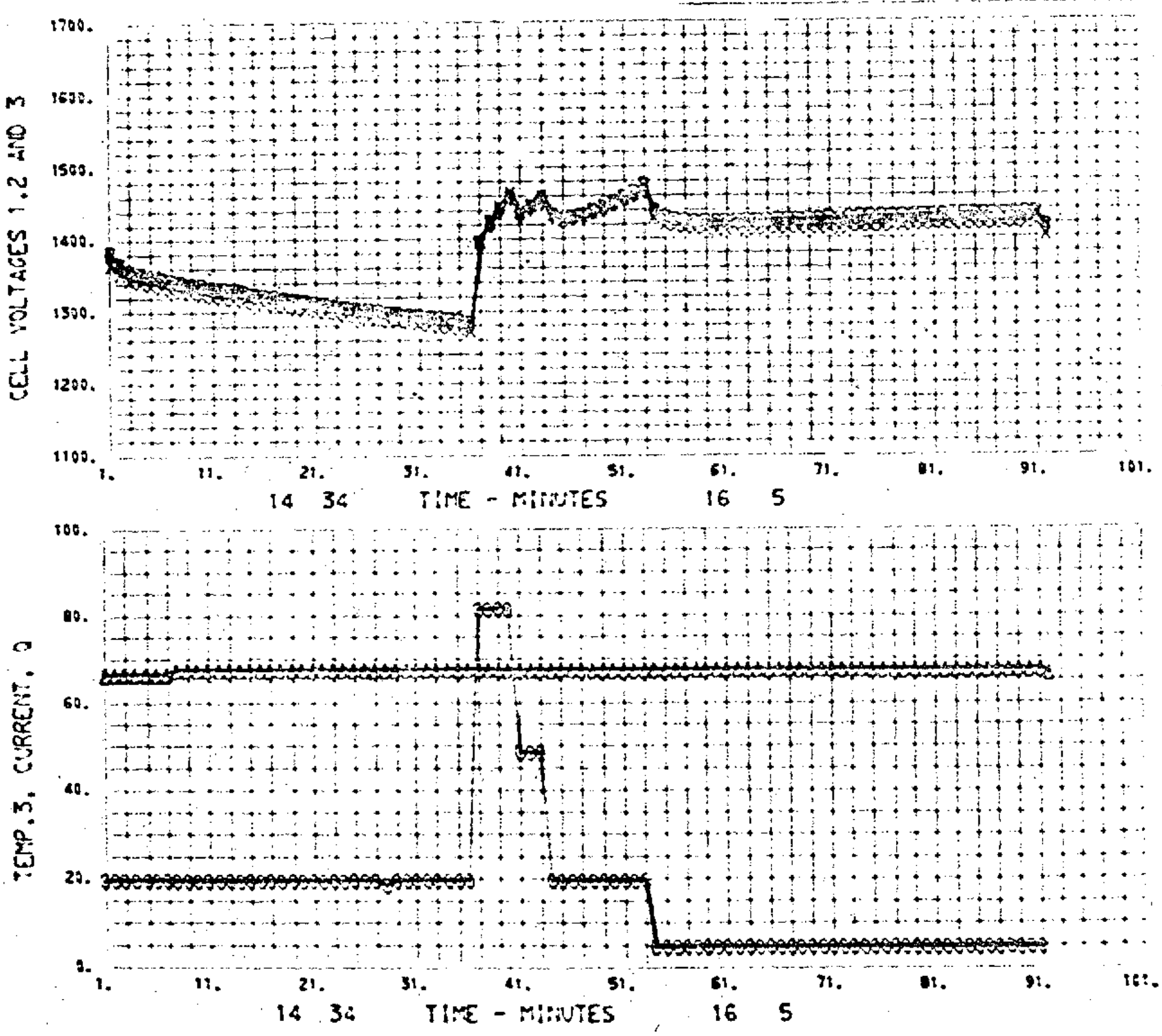
RUN NO. 1 ORBIT NO.431 STRING 7

FIG. 34

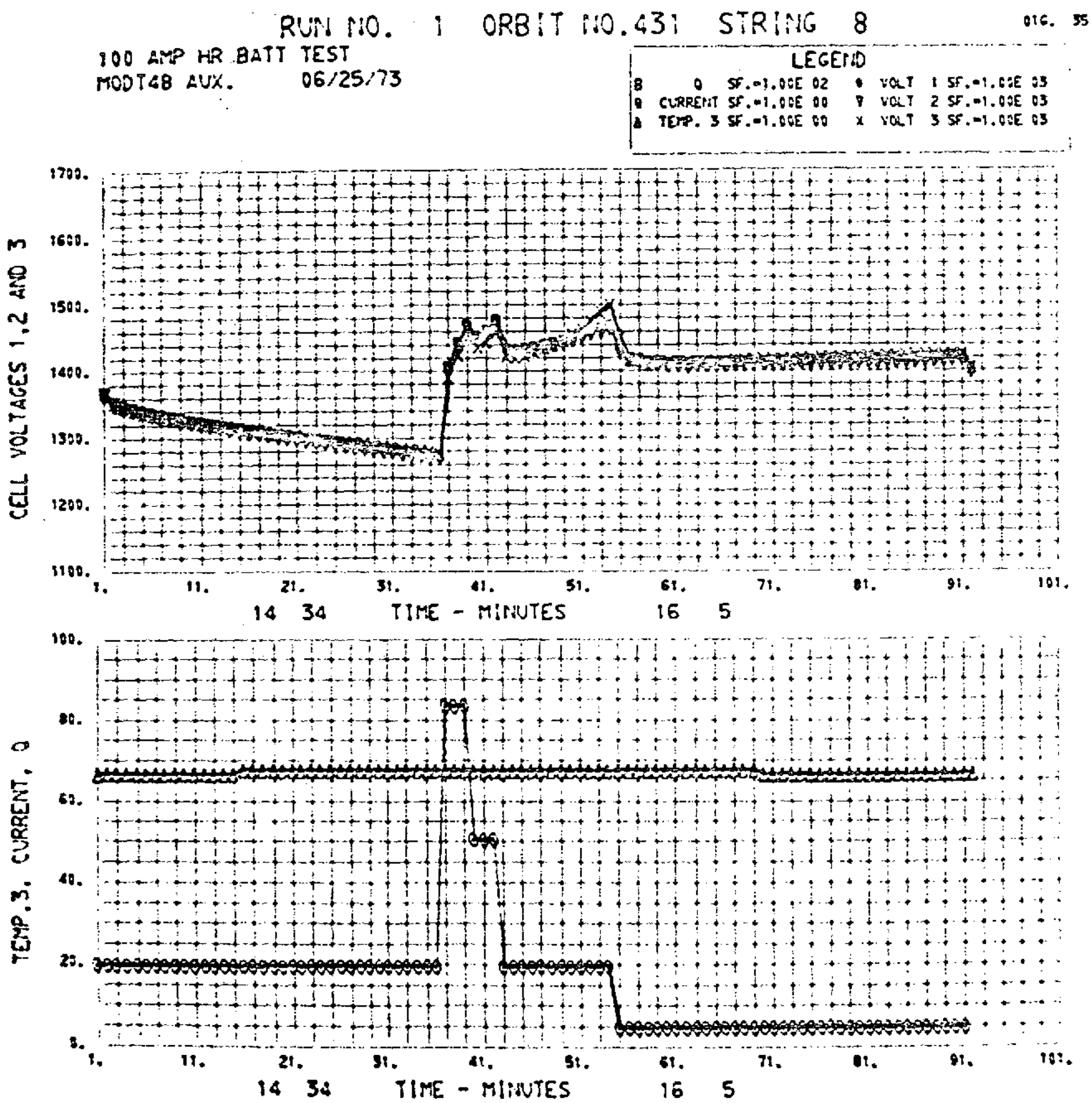
100 AMP HR BATT TEST
MODT48 AUX. 06/25/73

LEGEND

Q	SF.=1.00E 02	VOLT 1	SF.=1.00E 03
CURRENT	SF.=1.00E 00	VOLT 2	SF.=1.00E 03
TEMP. 3	SF.=1.00E 00	VOLT 3	SF.=1.00E 03

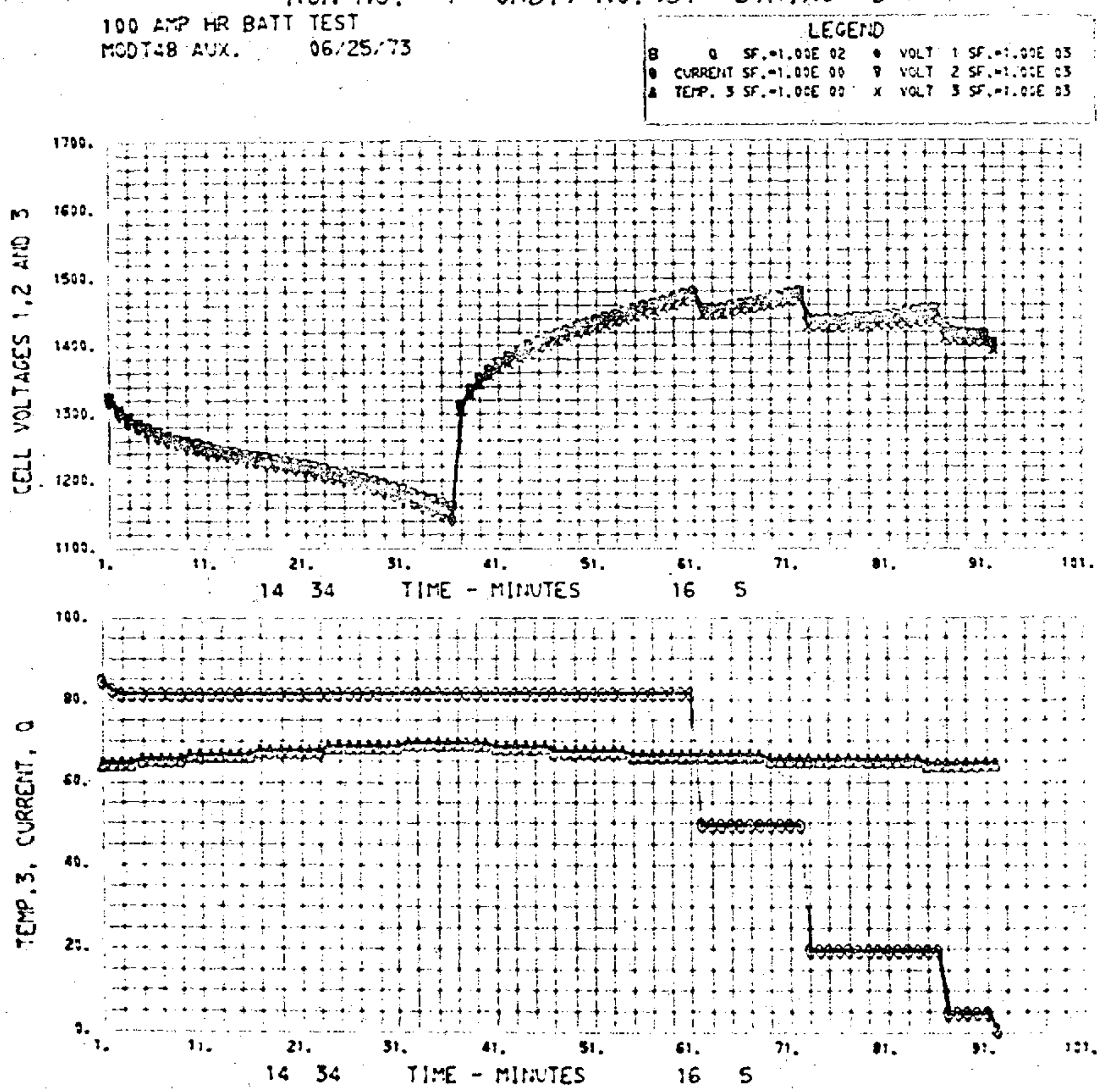


R5-45


RUN NO. 1 ORBIT NO.431 STRING 8
100 AMP HR BATT TEST
MODT4B AUX. 06/25/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
14 34 TIME - MINUTES 16 5
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
14 34 TIME - MINUTES 16 5

R5-46

RUN NO. 1 ORBIT NO.431 STRING 9

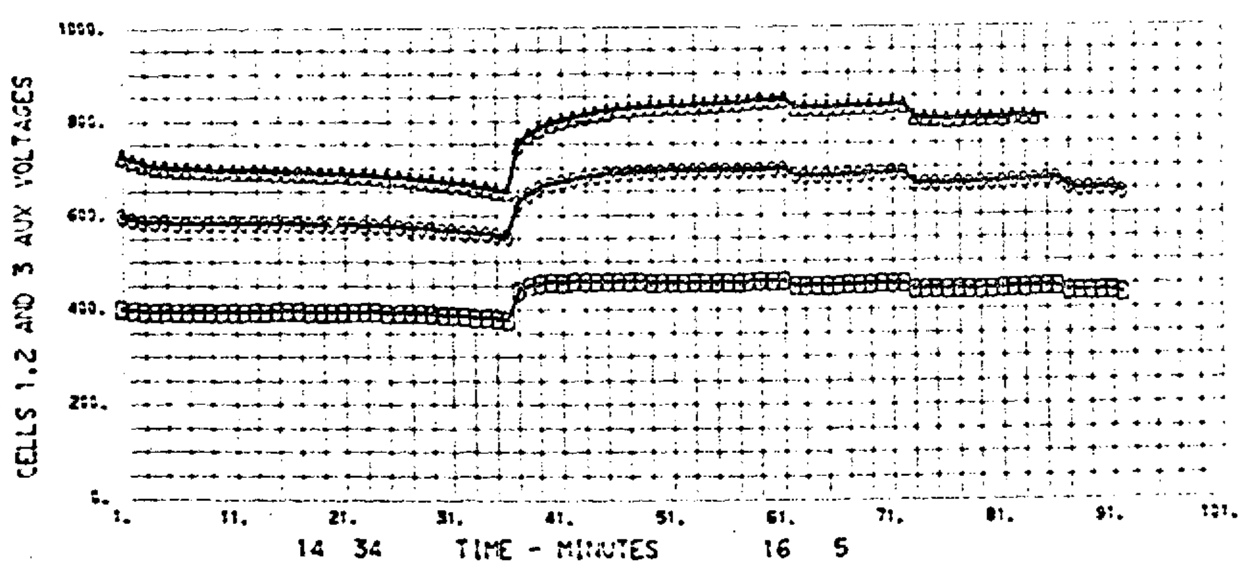


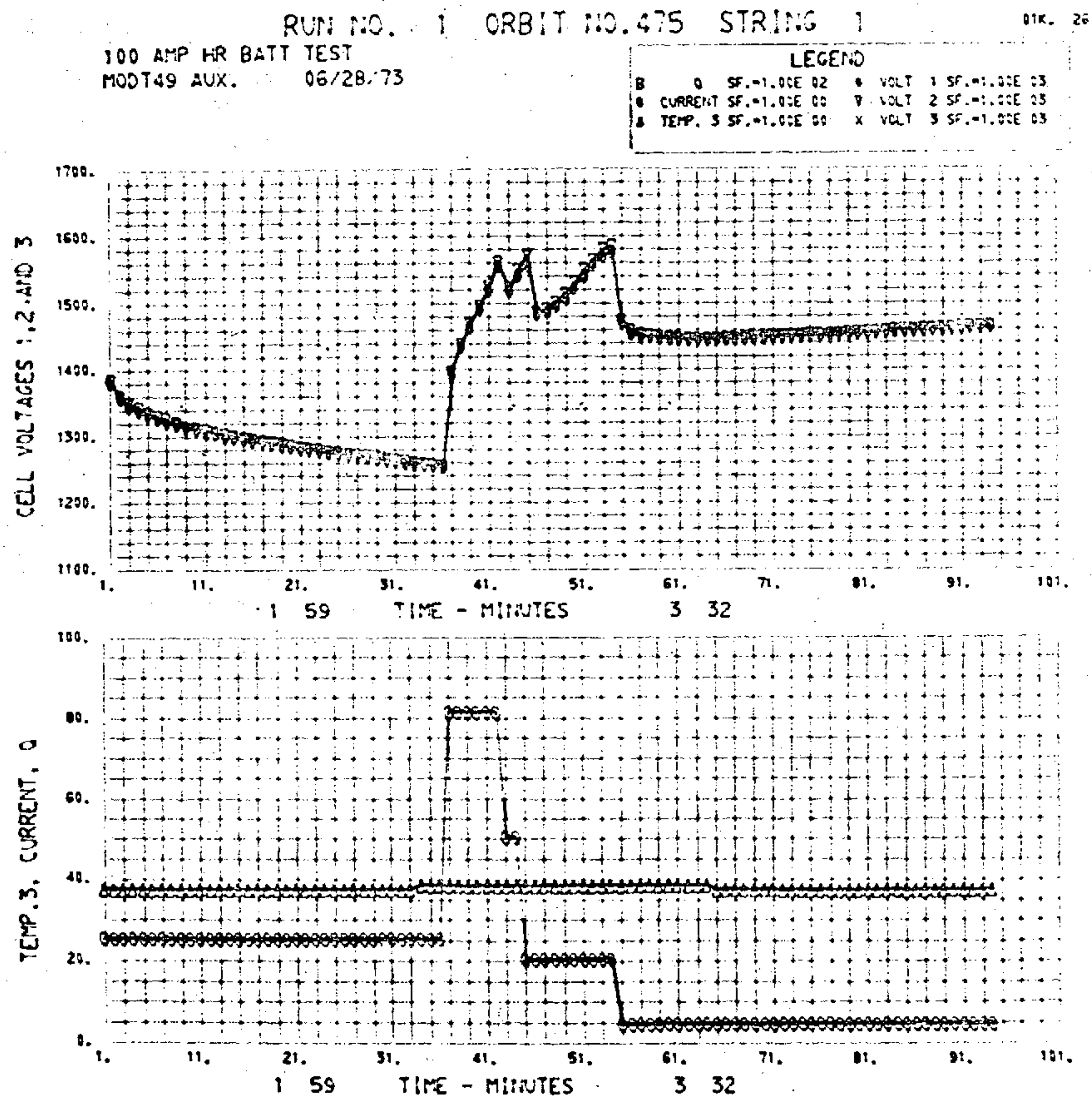
R5-47

RUN NO. 1 ORBIT NO.431 STRING 9

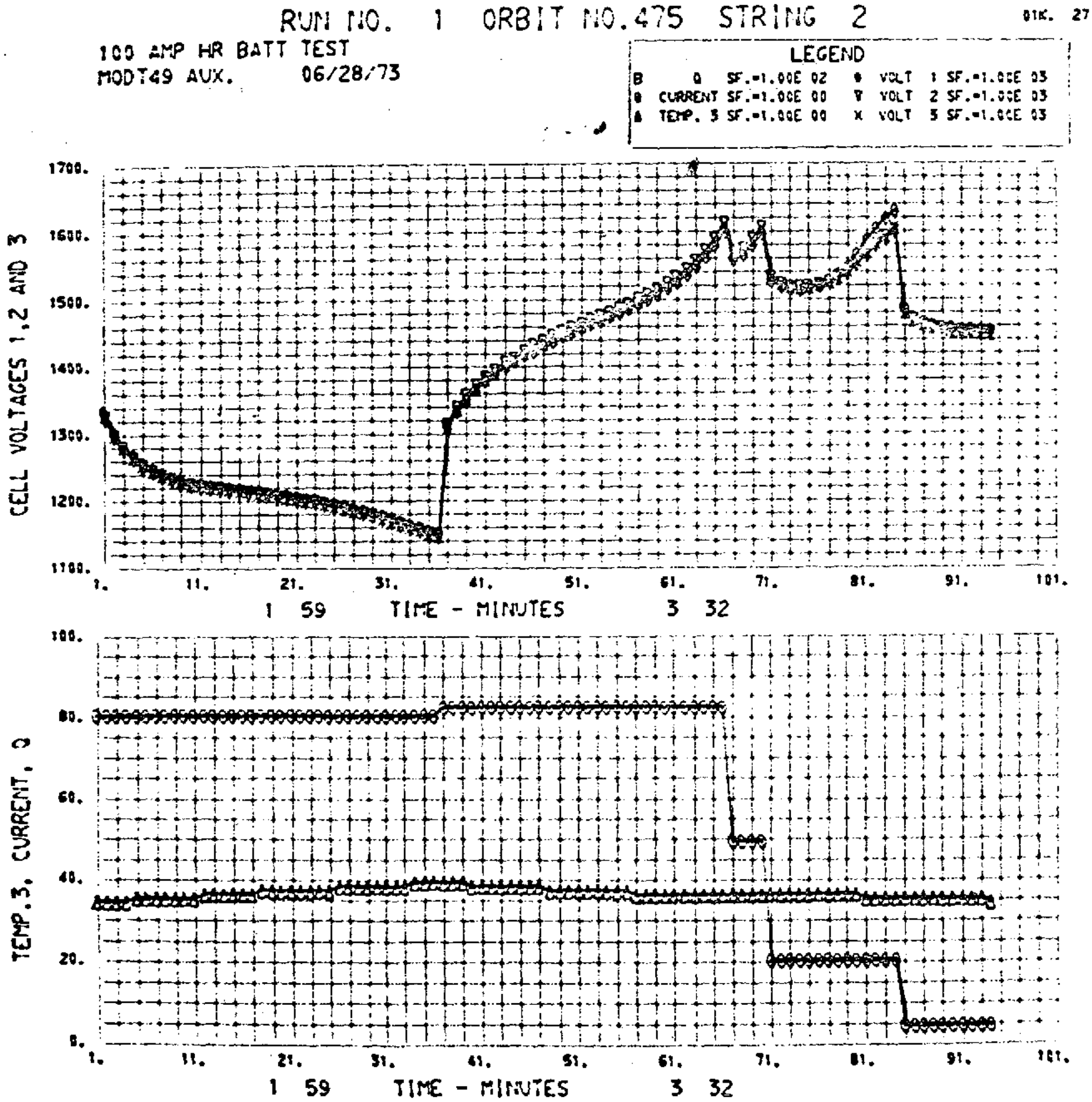
100 AMP HR BATT TEST

MODT4B AUX. 06/25/73




RUN NO. 1 ORBIT NO.475 STRING 1
100 AMP HR BATT TEST
MODT49 AUX. 06/28/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1 59 TIME - MINUTES 3 32
TEMP.3, CURRENT, Q
1 59 TIME - MINUTES 3 32

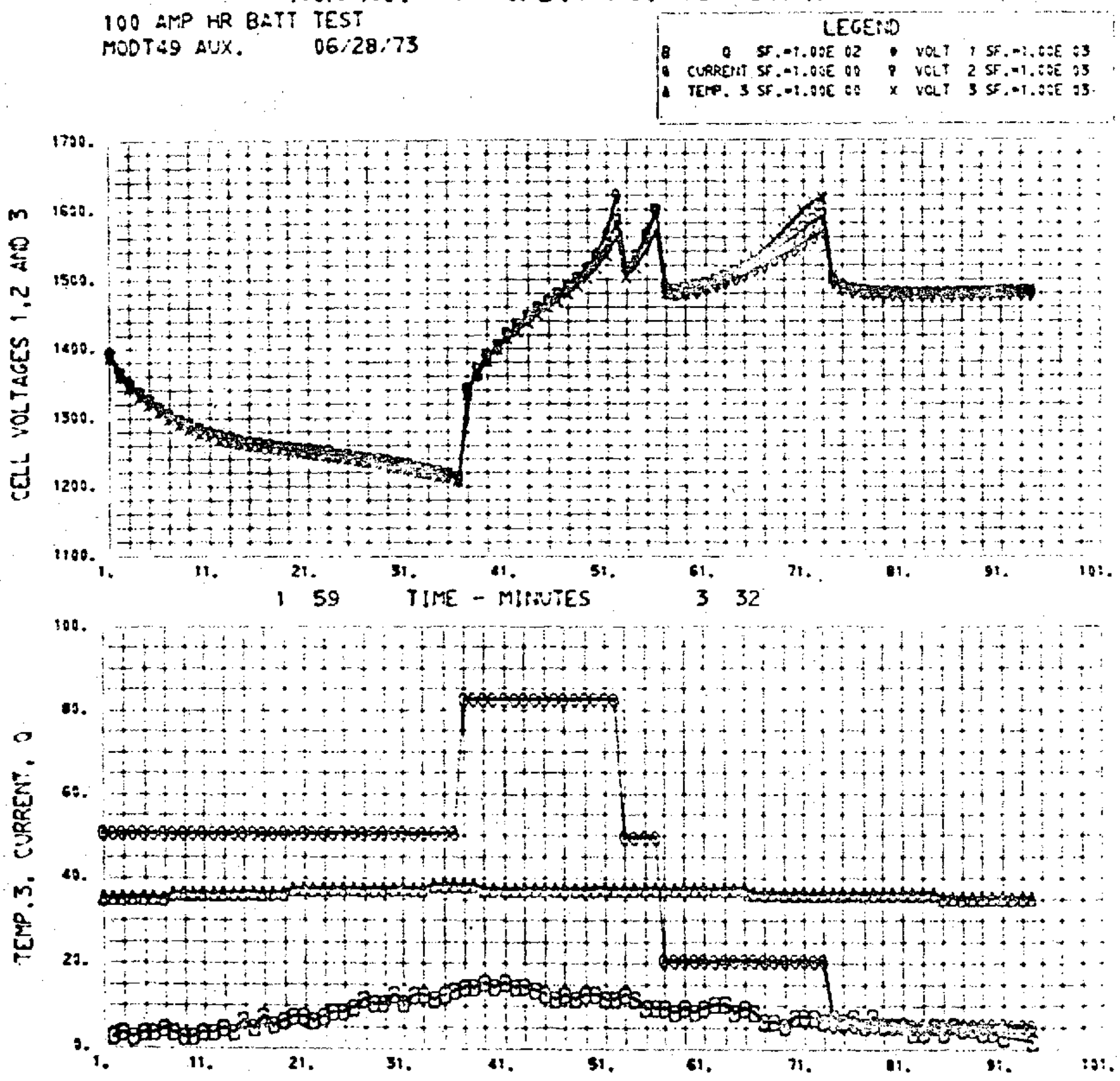
RS-49



RUN NO. 1 ORBIT NO.475 STRING 2
100 AMP HR BATT TEST
MODT49 AUX. 06/28/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1 59 TIME - MINUTES 3 32
TEMP.3, CURRENT, Q
1 59 TIME - MINUTES 3 32

RUN NO. 1 ORBIT NO. 475 STRING 3

100 AMP HR BATT TEST
MODT49 AUX. 06/28/73

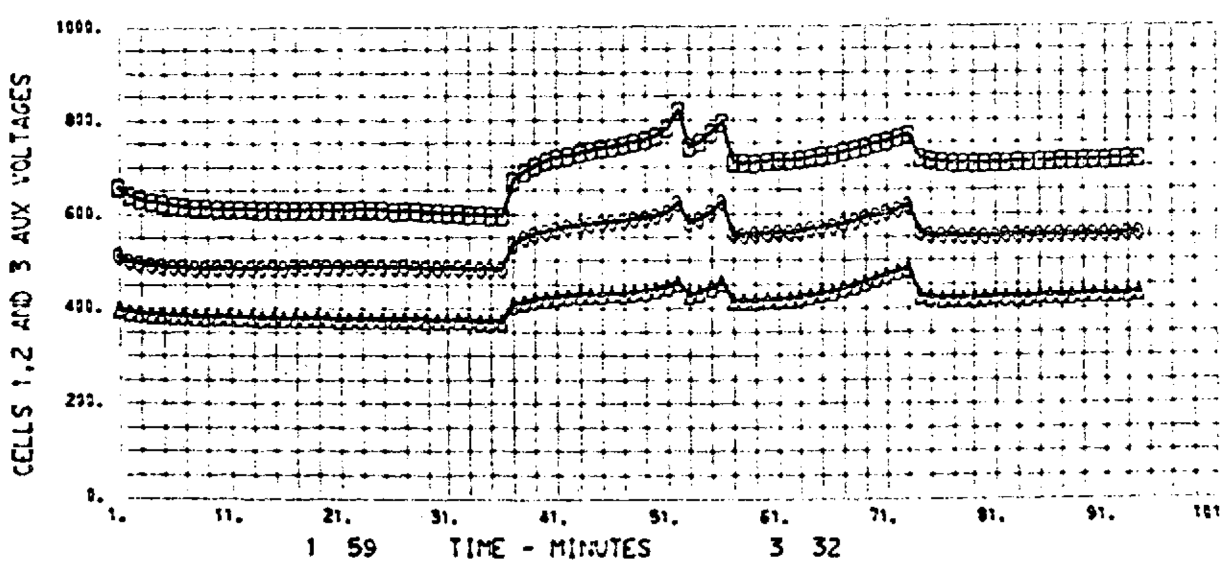


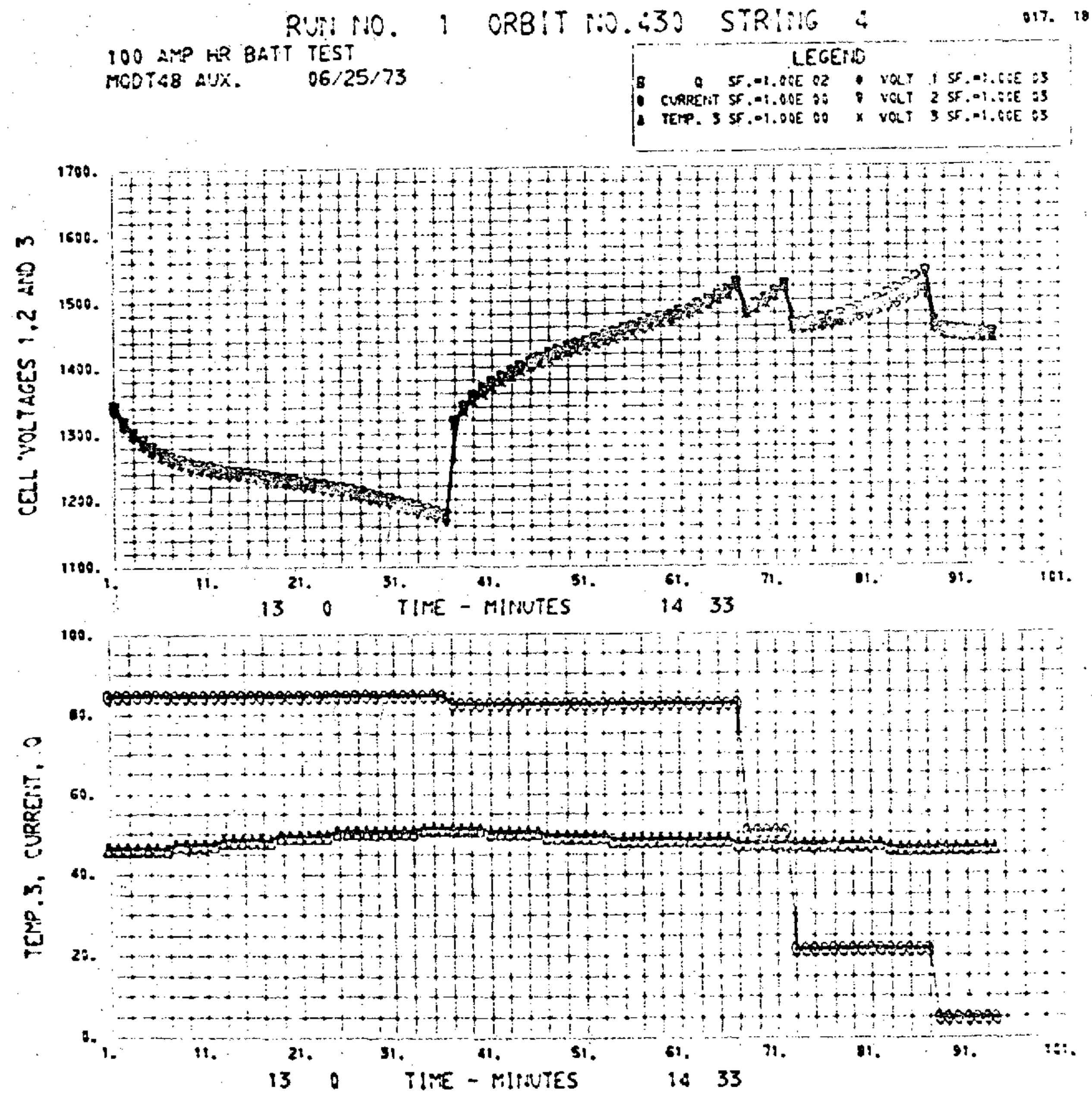
RF-51

RUN NO. 1 ORBIT NO.475 STRING 3

100 AMP HR BATT TEST
MODT49 AUX. 06/28/73

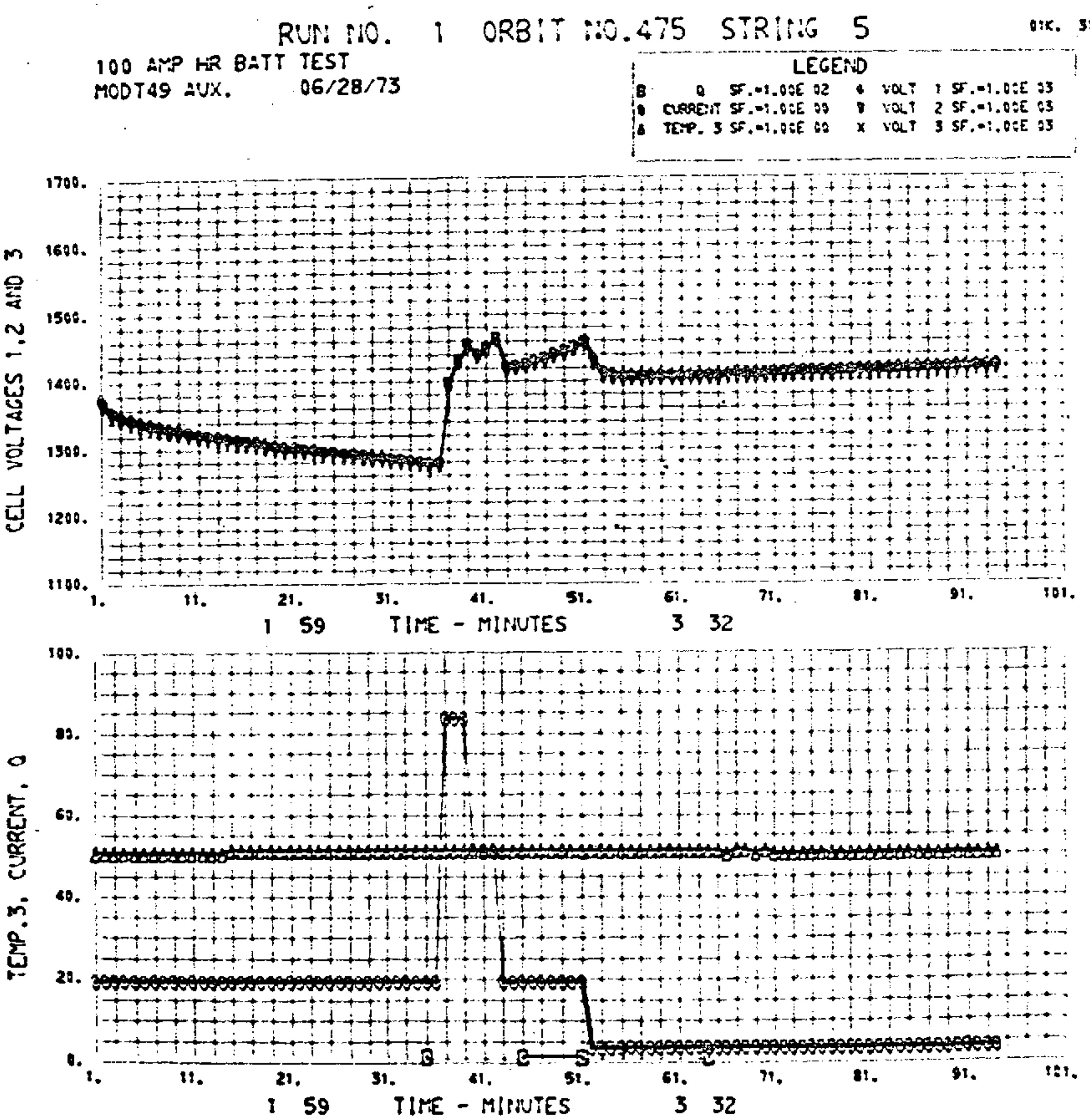
LEGEND
B AUX. 1 SF.=1.00E 03
B AUX. 2 SF.=1.00E 03
A AUX. 3 SF.=1.00E 03





RUN NO. 1 ORBIT NO.430 STRING 4
017. 18
100 AMP HR BATT TEST
MODT48 AUX. 06/25/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
13 0 TIME - MINUTES 14 33
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
13 0 TIME - MINUTES 14 33

RE-53

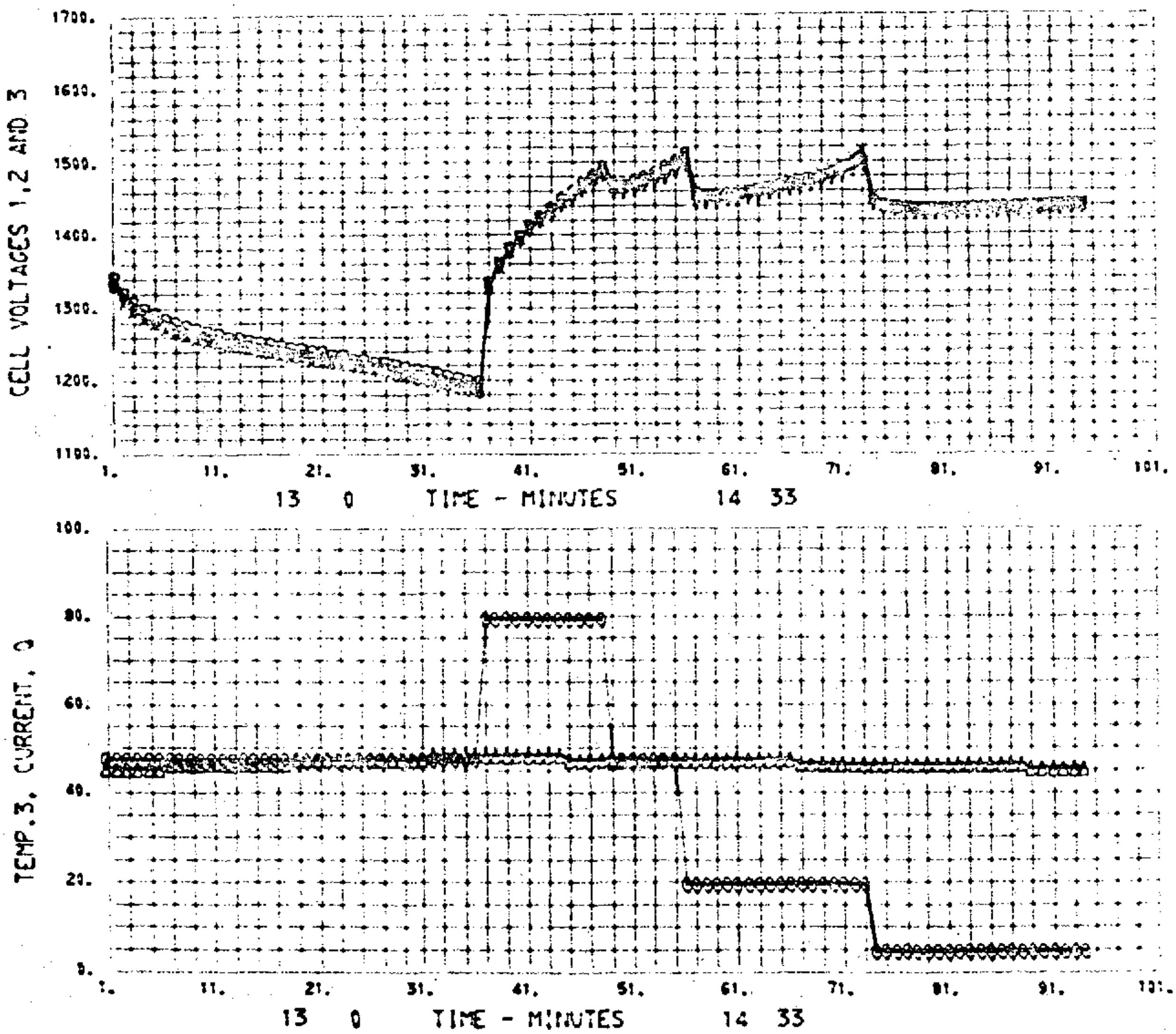

RUN NO. 1 ORBIT NO.475 STRING 5
100 AMP HR BATT TEST
MODT49 AUX. 06/28/73
LEGEND
Q SF.=1.00E 02
CURRENT SF.=1.00E 00
TEMP. 3 SF.=1.00E 00
VOLT 1 SF.=1.00E 03
VOLT 2 SF.=1.00E 03
VOLT 3 SF.=1.00E 03
CELL VOLTAGES 1,2 AND 3
1700.
1600.
1500.
1400.
1300.
1200.
1100.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
1 59 TIME - MINUTES 3 32
TEMP.3, CURRENT, Q
100.
80.
60.
40.
20.
0.
1. 11. 21. 31. 41. 51. 61. 71. 81. 91. 101.
1 59 TIME - MINUTES 3 32

RUN NO. 1 ORBIT NO.430 STRING 6 017. 20

100 AMP HR BATT TEST
MODT48 AUX. 06/25/73

LEGEND

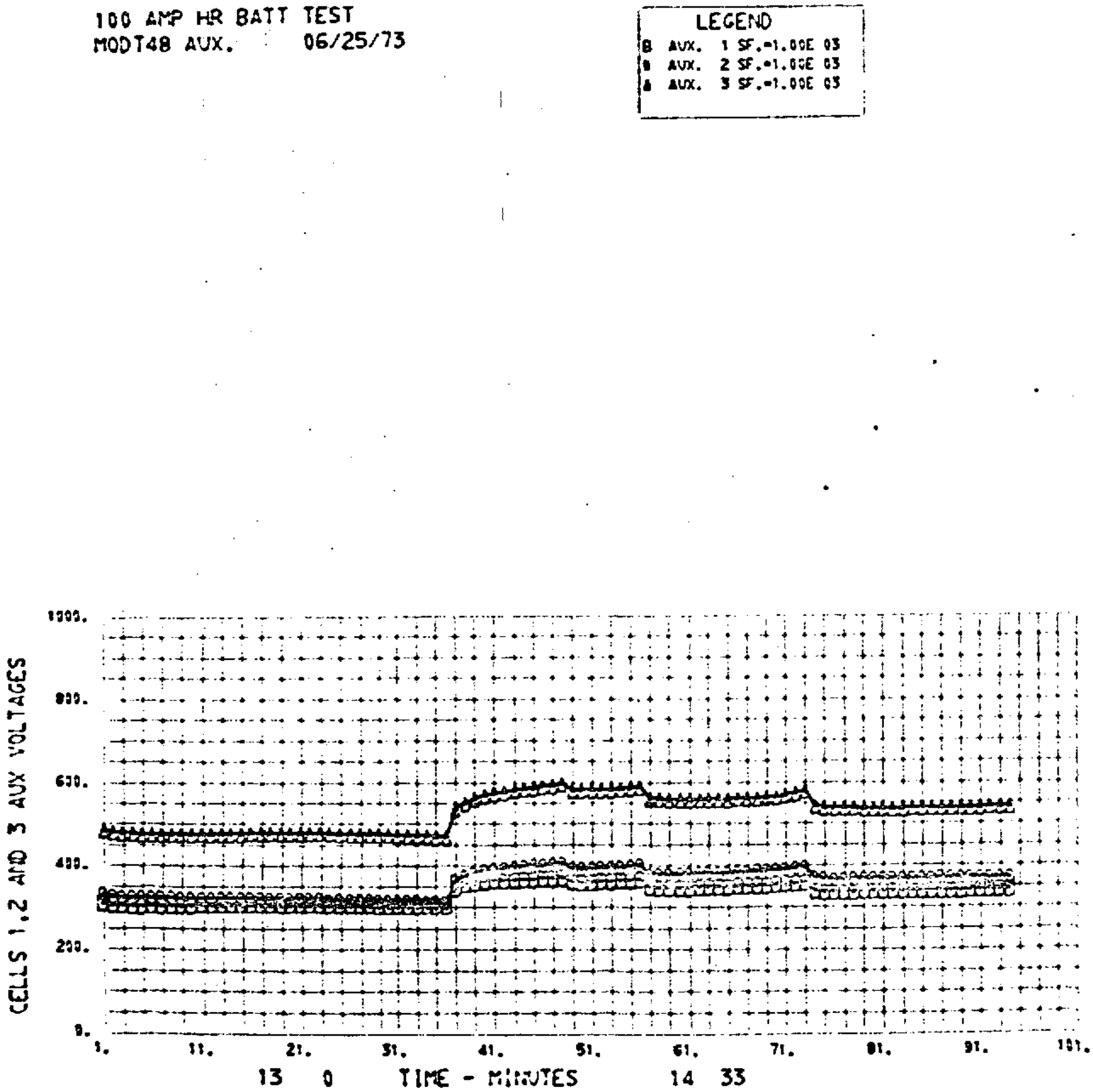
B Q SF.=1.00E 02 • VOLT 1 SF.=1.00E 03
• CURRENT SF.=1.00E 00 ▼ VOLT 2 SF.=1.00E 03
▲ TEMP. 3 SF.=1.00E 00 x VOLT 3 SF.=1.00E 03



RS-55

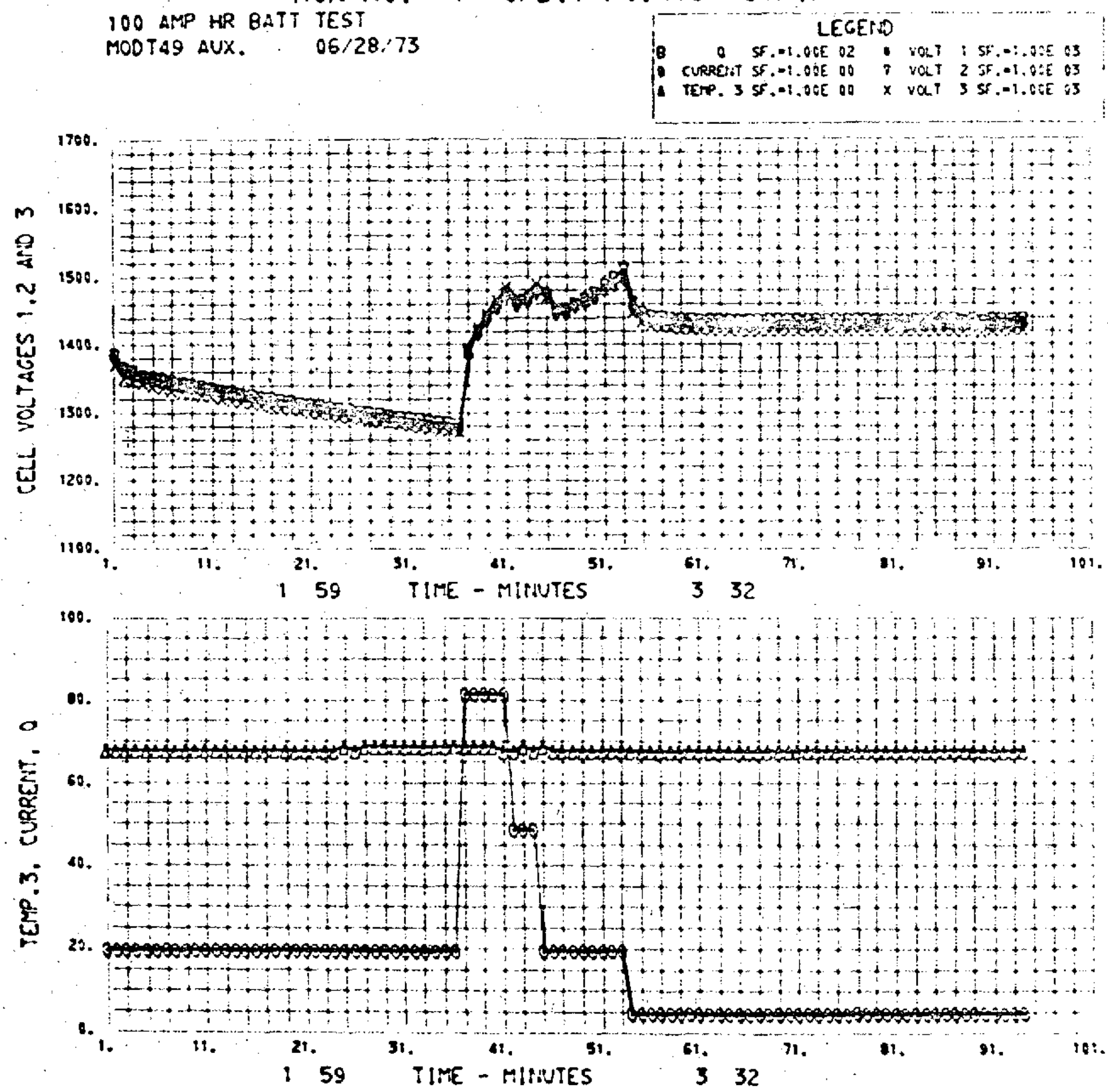
RUN NO. 1 ORBIT NO.430 STRING 6 017. 21

100 AMP HR BATT TEST
MODT48 AUX. 06/25/73



RUN NO. 1 ORBIT NO.475 STRING 7

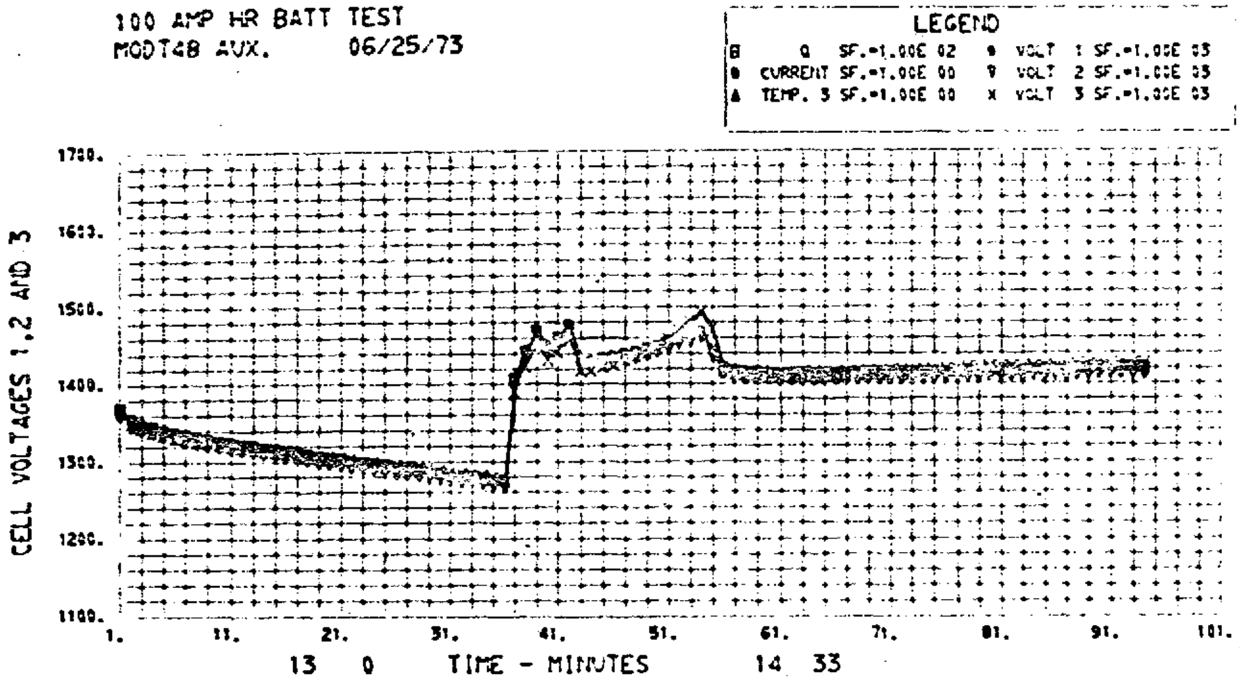
100 AMP HR BATT TEST
MODT49 AUX. 06/28/73

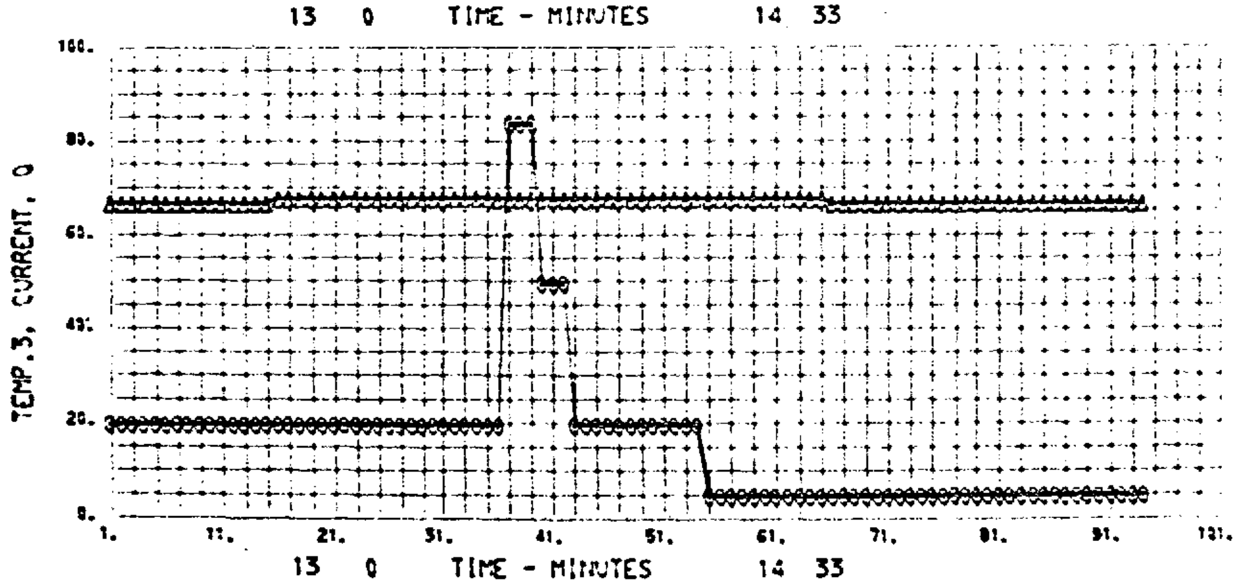


R5-57

RUN NO. 1 ORBIT NO.430 STRING 8 017. 23

100 AMP HR BATT TEST
MODT48 AUX. 06/25/73



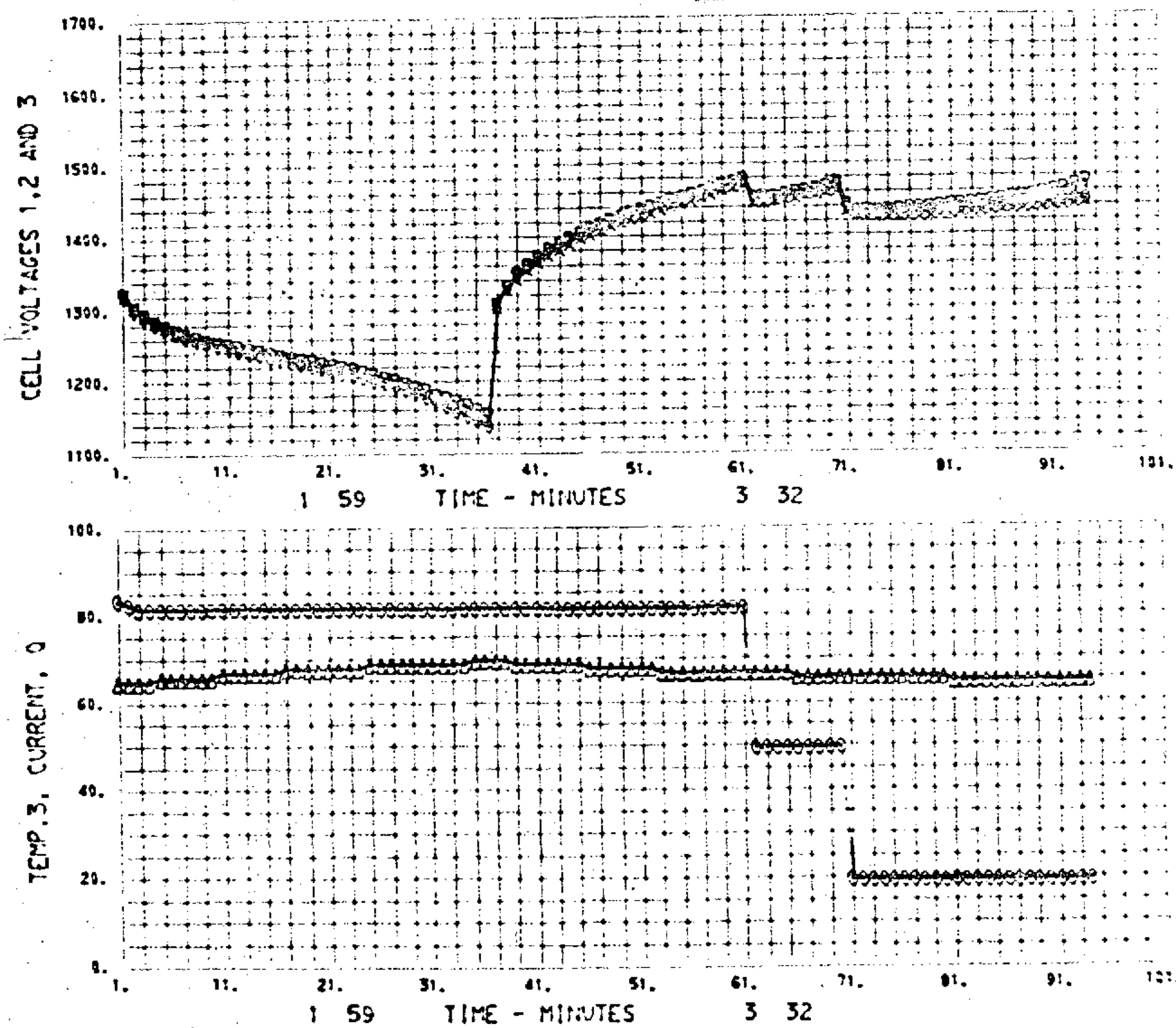


RUN NO. 1 ORBIT NO.475 STRING 9   01K. 36

100 AMP HR BATT TEST
MODT49 AUX. 06/28/73

LEGEND

Q	SF.=1.00E 02	VOLT 1	SF.=1.00E 03
CURRENT	SF.=1.00E 00	VOLT 2	SF.=1.00E 03
TEMP. 3	SF.=1.00E 00	VOLT 3	SF.=1.00E 03



R5-59

RUN NO. 1 ORBIT NO.475 STRING 9 BTK. 37

100 AMP HR BATT TEST
MODT49 AUX. 06/28/73